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E. H. STARLING

THE FEEDING OF NATIONS

The Oliver-Sharpey Lectures

on

The Feeding of Nations

A Study in Applied Physiology

BY

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PREFACE

When the council of the Royal College of Physicians honoured me with an invitation to deliver the Oliver-Sharpey Lectures, I was entirely absorbed, as Chairman of the Royal Society Food (War) Committee and as Scientific Adviser to the Food Ministry, in the scientific aspects of the national food supply. The still larger aspect of the same subject—viz. the apportionment of the available world supplies among the allied countries—was brought to my notice by my co-operation, as British Delegate, in the labours of the Inter-allied Scientific Food Commission. At that time the provision of food for the ensuing year, both for ourselves and for our allies, seemed very precarious, and likely to demand the utmost care, co-operation, and forethought, if the fighting powers of the Allies were to be maintained at their highest efficiency. No operations of the Government affect the comfort and habits of the individual so

closely as those involved in food control; and in view of the general interest in the subject, I thought that a slight sketch of the scientific principles, which must guide any successful attempt to interfere with the normal operations of the laws of supply and demand so as to secure equal and equitable treatment of every individual belonging to an allied country, might be of some value, not only to the Fellows of the College, but also to a wider circle of the general public.

With the freeing of tonnage that resulted from the Armistice, the immediate danger of a food-shortage in this country passed away, but only for the moment. Great as has been the sacrifice of human life during the five years of war, we have still to pay the penalty for the widespread and wanton destruction necessarily associated therewith. The devastation of millions of acres of fertile lands, and the destruction of working cattle and of means of transport have enormously diminished the production of food throughout Europe, so that there is an estimated deficiency in cereals alone for the coming European food-year of about 16 million tons. The optimistic forecasts of

the grain harvest in the American continent have not been realised, and it seems probable that not more than 14 million tons will be available to meet this deficit. At the same time, all the European nations, allied as well as enemy, are so impoverished by the war that they lack credit to buy even that which is available. And yet without an adequate food supply it is impossible to reconstruct a stable Europe or to insure its peace and tranquillity. The methods which proved successful during the war are still more imperatively required now and during the years of convalescence. The essential key-note of these methods was co-operative control based on exact knowledge. But the problem is now a bigger one, and affects no longer the Allies alone, but the whole of Europe. Enemies and Allies alike, we are all in the same boat, and unless we work together in harmony with a single view to the reintegration of a united Europe, we run imminent peril of economic shipwreck.

Already a great work has been done in this direction by the food section of the Supreme Economic Council, under the inspiring leadership of Mr. Hoover, ably

seconded by Sir William Goode, and the continuation and extension of this work is not only necessary for the safety of Europe but may prove the first realisation of that larger co-operation throughout the civilised world which is the dream of the League of Nations.

In these Lectures I have endeavoured to describe in plain language the elementary principles which must guide any measures devised to secure such common action in the feeding of the peoples of Europe. But I wish to emphasize the fact that I have dealt with the question entirely from the physiological standpoint. In the interpretation of these principles into administrative action there is a large field of economic science involved, with which I am not competent to deal.

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CHAPTER I

INTRODUCTION

MAN'S first care must always be the provision of his daily bread. No science was required to teach him that the satisfaction of his natural appetite—hunger—was a necessary condition of his existence, and that each day he must eat in order that he might have the strength to gain his bread of the morrow. The close relation of diet to health has been recognised by the medical profession from earliest times, and many aphorisms relating to this subject have been laid down and become part of medical tradition as a result of common experience. But the science of dietetics is of comparatively recent growth, and we owe to the researches of the last fifty years practically all the exact

knowledge we possess with regard to the process of digestion, the chemical composition of food, the significance of the energy of the food and its relation to the energy output of man in the form of work and heat.

These problems were attacked, however, almost exclusively with regard to the individual. The knowledge gained in their investigation served to enlighten the medical man in his dealings with his patients. Only in a few instances have the results been utilised for practical purposes connected with society as a whole or with large sections of the community. For example, the pre-war rations of our armies were fixed after a series of experiments on the food requirements of soldiers on the march. Again, in the valuable studies on poverty by Booth, Rowntree and others, full details are given of the diet of the poor and very poor, and deductions are made as to the sufficiency or otherwise of the earnings of these classes.

For the most part, the provisioning of a nation has been regarded as an economic question to be solved by the laws of supply

and demand; and it was not until the Great War fell upon Europe that certain of the nations involved awoke to the fact that the feeding of a nation as a mass was a physiological question, and that any efforts in this direction would be ineffectual or even disastrous unless they were based on physiological principles.

In spite of the fact that in all previous wars only a small fraction of the communities was directly involved, pestilence and famine have been their frequent companions. In the wars of to-day, in which every sound man is absorbed into the fighting forces, and when the greater part of the rest of the community must be employed in preparing the materials of war and is thus withdrawn from the production of food, there must be a universal interference with food production and food distribution; and the question of feeding the nation becomes one of the utmost difficulty. In fact, the view has been often put forward that a war under these conditions could not last more than a few months, on account of the universal exhaus-

tion of food and materials which would ensue; and, although this view was incorrect so far as concerns the actual duration, it was true in as much as the progressive impoverishment in food and material proved to be the main factor in bringing the war to a close and in deciding its outcome. The Germans themselves did not anticipate that a war of such duration would be possible. They were, however, the only nation who appreciated the importance of the food question during a European war, and, with this end in view, had for years strained every nerve to increase their home production of food, and to make their country self-supporting. The actual physiological requirements of Germany and the relation of these requirements to the country's resources in food were not, however, seriously considered until on the 4th of August England declared war on Germany, and the battle of the Marne destroyed all hopes of a speedy and decisive victory. The question at once presented itself whether Germany could hold out through a very long

war, if cut off entirely by the English blockade from its considerable importations of food and of fodder.

A body of scientific men, including, besides physiologists, political economists and statisticians, then undertook the study of these questions, and in December 1914 brought out a brochure giving the results of their investigations.[1] It is noteworthy that, even in Germany, where the State has learnt to rely in so many directions upon its scientific experts, it should have been left to a voluntary association of individuals to point out the questions involved, to draw up a budget comparing the food resources with the food requirements of the country, and to indicate the practical measures which would have to be taken if the balance in the budget were to be on the right side. But it is not surprising that in this country, imbued in its government departments with a contempt for

[1] Eltzbacher: *Die deutsche Volksernährung und der englische Aushungerungsplan.* Translated into English by Dr. Russell Wells, and published in 1915 by the University of London Press under the title: *Germany's Food. Can it last?*

science and the expert—a country in which the whole production of food had been regarded as a subject of negligible importance, and which still possessed the command of the seas and therefore the power to bring food from the markets of the whole world—at the beginning of the war the possibility of a food shortage and the necessity of taking scientific measures to cope with it hardly entered into the consciousness of our administrators. It was not until, by the development of submarine warfare, the Germans were able to limit considerably our facilities for shipping and import, that the provision of food for the nation was recognised to be the prime duty of the Government.

The great value of science to a country is that it gives prescience; and our Government might have fared ill in their attempt to provide for the population as a whole, if the contingency of a food shortage had not been foreseen by the chief organ of science in this country—viz. the Royal Society—so that a whole array of facts was at the disposal of the Government as soon as they were con-

vinced of the necessity of taking up this new war burden. At the very beginning of the war the Royal Society had founded a Physiological War Committee to advise government departments on any question involving knowledge of physiological principles, and in 1915 a Sub-Committee of this Committee was entrusted with the examination of all questions affecting food. Their first work was to examine, largely on the initiative of Dr. Waller, the conclusions arrived at in Eltzbacher's brochure with regard to Germany's food needs and supplies.

On this subject the Committee presented two reports to the Government. In the first one, dated 14th August, 1915, they showed that Germany, restricted to her home production of food, must suffer shortage, especially of proteins and fats, and that her adequate food supply could be secured only by considerable imports. In their second report on the same subject, in February 1916, they showed how their forecasts had been realised, and how in 1916 the situation of Germany in respect of food was still worse than in

1915. They also expressed their opinion that a predominant factor in the German economic situation was likely to be the shortage of available fats and oils, and pointed out the necessity for the most stringent limitation of imports of fats into Germany. Since the Armistice we have learned how true were these predictions, and how much might have been saved in the duration of the war if our statesmen had recognised the all-important part to be played by real restriction of the importation of foodstuffs into Germany.

The Committee then proceeded to make an estimate of the food supply of the United Kingdom, and to compare this with the food requirements of its inhabitants. In their first report, which deals with the food supply in the period before the war, 1909–1913, they point out that this problem is partly statistical and partly physiological. It is statistical because it is necessary first to ascertain as precisely as possible the quantities of the several foods available for human consumption in the United Kingdom. It is

physiological because it is then necessary to determine the adequacy of the available supply for the sustenance of the nation, and this depends upon :—

(1) The nutritive value of the several foods ;

(2) The standard requirements of the normal adult male as regards each of the constituents of food requisite for healthy activity ; and—

(3) The needs, in proportion to that standard, of women and children.

The report on this subject was presented to Government on 9th December, 1915.

In a second report on "Food Supply at the Present Period of the War (1916)," dated 29th July, 1916, the following significant remarks occur—

"The needs of our armies, the decreased yield of the harvest at home in 1916, and possible interference with our supplies from abroad, may reduce the supply in the future below this level.

"Up to the present the supply of food has provided a general margin of about 5 per

cent. above the minimum necessary for proper nutrition, and rather more as regards the supply of energy, so that a reduction to this extent would still furnish amounts of the essential food constituents conforming to the standard adopted in Part I. of our Report. Should such a reduction occur, it could be borne without serious injury to the community, but only on the condition that steps were taken to ensure the equitable distribution of the available food throughout the population.

"While the supply of food has, up to the present, been adequate for the support of the population, the rise in prices has accentuated the inequalities of distribution, which reduce the daily ration of many below the level of efficiency. Any curtailment of supplies, even to a limited extent, would result in the poorer classes obtaining less than is needful for safety should distribution remain unorganised.

"The Committee, as physiologists, desire to lay stress on the fact that in buying food the labouring population is buying energy—the

power to do work. Increased cost of food (other things being equal) means increased cost of production. If the rising prices curtail for any class of the community its accustomed supply of food, its output of work will, of necessity, be reduced. It is important to remember that a slight reduction of food below the necessary amount causes a large diminution in the working efficiency of the individual."

In the third part of the report of the same date, the Committee put forward possible methods of economising the available food supply, among these suggestions being—

(1) A higher recovery of flour in milling.

(2) Increased economy in meat production.

(3) An increase in the manufacture of cheese at the expense of butter.

(4) The use as food of materials at present employed in brewing and distilling; and—

(5) The diversion of certain quantities of material used for stock feeding to human food.

Of these suggestions all except number (2) were finally adopted by the Government and enforced on the community.

In connection with the policy advocated by the Committee a host of subordinate questions had to be taken into account, and memoranda on these, amounting, up to 1919, to about sixty in number, were drawn up for the information of the Government.

The assumption of control by Government was, however, tardy, and at first partial. The Royal Sugar Commission was appointed in August 1914, and the Royal Commission on Wheat Supplies in October 1916, and in December 1916 a Ministry of Food came into being, with a member of the government at its head as Food Controller. It was not, however, till the appointment of Lord Rhondda as Food Controller in June 1917 that scientific principles obtained their proper place in the determination of policy, and the system of measures, of which I shall have some occasion to speak later on, was brought into force. From this time on the Royal Society Committee acted practically as

a scientific consultative committee in all matters of food supply; the close co-operation between the Food Ministry and the Committee being secured by the appointment of Sir William Thompson as Scientific Adviser to the Ministry.

The basing of the policy of a Ministry on scientific principles, and the close co-operation between administrators and a scientific committee, must be regarded as a welcome innovation in the conduct of the affairs of the nation and as responsible for the marked success of the food policy in this country. In no other country, either among our enemies or allies, has the victualling of the nation been carried out so efficiently and with so little friction.

When, towards the end of 1917, it was decided to pool the resources and supplies of all the allied countries in order to obtain complete unity of action, and to utilise to their full extent the forces at the disposal of the Allies, it became necessary to devise some means analogous to those already adopted in this country, so that the results of

science might serve as a basis for the partition of available supplies among the Allies. To this end it was decided at the Inter-allied Conference at Versailles in November 1917 to appoint an Inter-allied Scientific Food Commission, with two delegates from each of the countries—Great Britain, United States, Italy and France. The task of this Commission would be to examine from a scientific standpoint the Inter-allied food problem, and to propose to the allied Governments, in consultation with the appropriate executives, any measures which it might think fit.

This Commission met for the first time at Paris in March 1918. In the introduction to their first report it is stated that—

"The question of partition has, up till now, been decided by a species of bargaining and by an endeavour to adjust the demands of each allied nation on the common stock, so as to secure to each the share which past experience indicated as necessary. The requirements of each description of food have been settled independently of any general

food programme ; *e. g.* cereals by the Wheat Executive, without reference to the fat or meat programmes which must affect the need for cereals. Any method of distribution must, however, be unsatisfactory in the absence of precise knowledge both as to the resources and as to the needs of each nation. The *needs* of a country depend on ascertained physiological facts, and can be deduced from a knowledge of the nutritional requirements of its inhabitants of varying age and sex as well as of the distribution of these classes of individuals among the population. The question is therefore fundamentally a physiological one. The resources of a country can be gathered from the statistical information at the disposal of its Government with regard to agricultural production, trade returns, etc., but the value of these resources as human food and the extent to which they can be employed to meet the needs of the population are questions which can be determined only by recourse to physiological data."

The first work of this Commission was to

undertake a survey of the food situation, on which the administrators concerned could base their practical measures. It also presented to the various Governments reports dealing with the whole basis of food production and of food distribution under war conditions.

I do not propose in these lectures to give a full account of the activities, either of the Royal Society Committee or of the Inter-allied Commission, but rather to discuss the problem as it appeared to the Inter-allied Scientific Commission, and as it must present itself in the future to any Government which is charged with the responsibility of controlling the whole question of production, supply, and distribution of food to its armies, militant and industrial.

The subject falls naturally under three headings, viz.—

(1) The actual requirements of the population.

(2) The provision of the necessary food, whether by production in the country itself, or by purchase and importation.

(3) The distribution of the food so obtained equitably among the population, so that each may receive according to his or her needs.

In all three problems physiological principles are closely concerned, and success will depend on the proper appreciation of these principles.

CHAPTER II

FOOD REQUIREMENTS OF A NATION

When we consider the heterogeneous character of the inhabitants of a country, and that the energy output varies from individual to individual according to age, sex, size, occupation and environment, and when we take into account the thousand and one articles which are employed as food in order to furnish this energy, it seems at first sight a hopeless task to endeavour to appraise the total needs of the community.

On further examination the problem shows itself capable of simplification. In the first place, given a fair choice of foods, a human being, guided only by his appetite, will choose a combination containing adequate proportions of the various foodstuffs. On this supposition, we can reckon all kinds of foods according to the energy which they will afford to the body

when digested. In our first calculation, therefore, we can measure all food in terms of its energy value reckoned as Calories, and we can confine our attention to the total number of Calories which must be furnished in the form of food to the population per day or per year. This involves a calculation of the energy requirements in Calories of the total population.

Food Requirements of Men

Although no two men are exactly alike, we can speak of an average man in relation to his size and weight. The average output of a man can be divided into two parts, one part which is a function of his surface, called the 'basal metabolism,' and the other part depending on the amount of external work which he performs. If we know the number of men in the community, and their average size and weight, we can calculate the surface of the average man, and therefore the total energy requirements of the adult male population.

When a man is resting as completely as

possible, *e.g.* in bed, he is continually expending a certain amount of energy in order to keep himself alive and to maintain his body temperature. Work is being done by the heart and by the muscles of respiration, and there is a continuous slight activity of all or most of the muscles of the body. This expenditure of energy at rest is the *basal metabolism* of the individual. It may be determined by measuring in a calorimeter the total heat given off by the man, or by finding out how much oxygen he is using up and therefore the amount of oxidation which is going on in the body. The basal metabolism may be defined as the metabolism or total oxidative changes of a man under ordinary conditions of nourishment, but with the body and the digestive organs at rest. It is the metabolism of a man at rest in bed before breakfast. It is found that this basal metabolism is in direct proportion to the extent of surface of the body. The surface can be calculated, if we know the weight and height of the individual, by Du Bois' formula:

$$S = \cdot 007184 \times W^{0 \cdot 425} \times H^{0 \cdot 725},$$

where S is the surface in square metres, W the weight in kilograms, and H the height in centimetres.

The mean of a number of observations shows that in an adult man between 20 and 50 the basal metabolism = 39·7 Calories per square metre of surface per hour. A man of average height and weight would have a surface of 1·772 square metre and a basal metabolism of 70·3 Calories per hour, or of 1,687 Calories per 24 hours. The basal metabolism is increased by the taking of food, so that a certain allowance must be made for this increase, apart from the increased metabolism incident on muscular work.

More difficulty is presented by the task of determining the average expenditure of energy by the adult male population in the work involved either in their bodily movements or in their normal avocations. The amount of work involved in different occupations differs enormously. It is usual to assume that the average amount per man of all the work done by the total male population

may be represented as that done by a man of average weight, working moderately for eight hours per day. The difficulty then arises at what figure we are to assess this moderate work. Vott defined the average as work performed during 9 to 10 hours, which was not so light as that of a tailor, nor so heavy as that of a blacksmith, and which would correspond approximately to that of a bricklayer, carpenter, or joiner.

Such a definition can hardly be regarded as scientific. Greenwood compares it to the case in which a motorist, who wishes to know how much petrol he should take on board, is informed that he is going further than Barnet, but not so far as John o' Groats. The most obvious method would be to define work by the number of kilogrammetres performed by a man in the course of eight hours. It has been shown by Waller that a young man may perform in eight hours about 100,000 kilogrammetres of work in raising his own body by going up a staircase, without undue fatigue. Such work is carried out by the largest muscles of the body, and

under the most favourable mechanical conditions. In such circumstances we should find that during the work the total excess of output of energy over the individual's basal metabolism corresponded to about four times the Calorie value of the work performed. In such a case the mechanical efficiency of the body is spoken of as equal to 25 per cent. 102,000 kilogrammetres of work are equivalent to 240 Calories. With a mechanical efficiency of 25 per cent., the body will therefore expend 240×4, which equals 960 Calories, in the performance of this work.

This however does not include the whole of a man's activities. Every change of posture, every movement, every exposure to cold air in going out of doors involves an increase over the basal metabolism. Lusk gives the following table as showing the influence of change in posture on metabolism—

Occupation.	Increase in the Basal Metabolism in per cent.
Sitting	5
Standing, relaxed	10
Standing, hand on staff	11
Standing, "attention"	14

On the average we may say that the metabolism of a man, when he is up and about a well-warmed room before breakfast doing no special work, is about 10 per cent. above the basal metabolism. We know however that the ingestion of food increases this metabolism, so that, for instance, the same man under the same conditions after breakfast would be expending more than the basal energy *plus* 10 per cent. We greatly need further experimental evidence as to the average excess, but in the present state of knowledge we should increase the 10 to 20 so as to allow for the influence of the food factor. For the numerous little activities of ordinary life, with exposure to variations of temperature in passing from one room to another and out of doors, we should allow another 10 per cent., making in all 30 per cent. above the basal metabolism.

On these assumptions we may make the following calculations as to the energy output of the average man. The average surface may be calculated by the formula already

given from tables showing the main heights and weights of adult men.

These are as follows :—

MEAN HEIGHTS AND WEIGHTS.

	Men. Height.	Weight.
American and Canadian insured persons, 1912	5 ft. 8·5 ins. (174 cm.)	155 lbs. (70·3 kilos)
The British Association (1883) found for England (ages 20–50)	5 ft. 7·4 ins. (171 cm.)	155 lbs. (70·3 kilos)

The above weights are with clothes. Therefore, before computing surface, 10 lbs. must be subtracted from them to allow for the weight of the clothes.

The surfaces are then found to be—

Americans	1·792
English	1·772

It will be advisable to adopt the American figures, since they are more recent, and based on a larger number of individuals. Taking 39·7 Calories per square metre surface as basal, and assuming an 'efficiency' of 25 per cent., the following results are obtained—

	Calories.
8 hours' sleep at 71·1 (basal metabolism) .	568·8
8 hours awake at 92·4 (basal metabolism + 30 per cent.)	739·2
8 hours' work (basal metabolism + 240 × 4 = 568·8 + 960)	1,528·8
	2,836·8
Adding for locomotion and travelling . .	300·0
	3,136·8

a little more than 3000 Calories per day.

How far are we justified in taking this figure as representing the average output of the adult man of all occupations? In the calculation above given we have included an allowance for the expenditure of energy involved in travelling between home and place of occupation. Lusk has found that a man of average weight gives out extra 172 Calories if he walks three miles in one hour, and 484 Calories if he trots 5·3 miles in the same time. These figures were obtained in the most favourable circumstances as to external temperature, ease of movement, absence of load, etc. It would appear fair therefore to allow an expenditure of 300 Calories per day

for the purposes of locomotion, and that should be allowed, whatever the nature of the occupation.

On the other hand, a very large percentage of the population do not perform anything like 102,000 kilogrammetres of work, nor do they expend 960 Calories in the performance of external work. Nor can we in various occupations determine to any degree of accuracy the number of kilogrammetres of external work actually performed. This would be easy enough in the case of a treadmill, but it is practically impossible in the case of the varied movements connected in the work of a carpenter. Moreover, the metabolic cost—*i.e.* the relation of energy set free in the body to the mechanical work performed—varies according to the muscles employed, to the position of the man, and to the rate at which he works. Thus it seems probable that work with small muscles, —*e.g.* arm work—requires the expenditure of a greater number of Calories per kilogrammetre of work than is the case when equal

work is done by the large muscles, such as those of the thighs. Indeed, when we are dealing with dietetics, the essential factor is, not the mechanical value of the external work done, but the amount of energy which must be expended by the body in order to perform the work. Our classification of various occupations into light, moderate or heavy should therefore be based, not on the kilogrammetres of work done, but on the Calories of energy expended by the body, since on this depends the diet which must be assigned to different classes of workers.

The Food (War) Committee of the Royal Society has suggested the following classification—

Sedentary . . .	Less than 400 Calories.
Light work . . .	400 to 700 Calories.
Moderate work . .	700 to 1,100 Calories.
Heavy work . .	1,100 to 2,000 Calories.

and, taking certain figures acknowledgedly inadequate given by Becker and Hämäläinen, the following table of total energy requirements for different occupations—

Occupation.	Energy requirements.	Food requirements.
Tailor	2,500 Calories.	2,750 Calories.
Bookbinder	2,800 "	3,100 "
Shoemaker	2,850 "	3,150 "
Metal worker	3,200 "	3,500 "
Painter	3,250 "	3,600 "
Carpenter	3,200 "	3,500 "
Stonemason	4,400 "	4,850 "
Woodcutter	5,000 "	5,500 "

It will be seen that the first three of these fall below the 3,000 Calories taken as the energy expenditure of the average man, while the last five come above them. It would seem therefore that the assumption that the energy expenditure of the average man amounts to 3,000 Calories per diem may be fair in the case of a country such as the United Kingdom, where such a large proportion of the population is engaged in sedentary pursuits, which are certainly not more arduous than those of the tailor. Among these sedentary pursuits would be reckoned all classes of brain workers. In a country in which the population was chiefly agricultural the allowance of 3,000 Calories might prove to be inadequate.

In reckoning the amount of food necessary to meet this energy expenditure, it is usual to add 10 per cent. to cover the difference between the food as digested and the food as purchased, so that 3,000 Calories per day energy expenditure would involve the provision of a daily ration with a Calorie value of 3,300 for each adult male of the population.

Food Requirements of Women

In consequence of their smaller size, women have a smaller surface area and therefore a lesser basal metabolism than man. But it has been shown by Dubois and others that, apart from this difference in size, the basal metabolism of women per square metre is only 93 per cent. of that of a man, so that, whereas in man the average Calorie output is 40 Calories per square metre, in woman it is only 37 Calories per square metre of body surface per hour.

The mean heights and weights of English

and American women respectively are given in the following table—

	Americans and Canadians (1912).	British (1883).
Height	5 ft. 4·5 ins. (163·8 cm.)	5 ft. 2·7 ins. (159·3 cm.)
Weight (clothed)	134 lbs. (60·8 kilos)	122·8 lbs. (55·7 kilos)

Allowing 10 lbs. for weight of clothes, the surfaces are then found to be—

Americans	1·605 sq. metres.
English	1·511 ,, ,,

In calculating the minimum energy requirements of the average working woman, we have to take into account that in very few circumstances is she capable of carrying out the amount of external work undertaken by a man. It is usual in the replacement of men by women in works to allow three women for the work of two men, and it seems a fair assumption to take the mechanical work of the average woman as equivalent to two-thirds that of a man.

On this basis we can calculate the minimum energy requirements of the average working woman as follows—

	Americans.	English.	
8 hours' sleep at 59·4, or 55·9 (basal)	475·2	447·2	Cals.
8 hours awake at 77·2, or 72·7 (basal + 30 %). . . .	617·6	581·6	,,
68,000 kgm. work	640	640	,,
8 hours at basal	475·2	447·2	,,
Total . . .	2,208	2,116	,,

In the case of the man we allowed 300 Calories per day for purposes of locomotion. For the lighter woman 240 Calories would suffice for the same distance, and since few women would walk so far as five miles, an allowance of 240 Calories will leave a certain remainder available for the household work, which bulks so largely in woman's activities.

Using the scanty determinations of actual metabolism made by Becker and Hämäläinen, we may calculate the total energy requirements for certain classes of occupation. The resting metabolism of woman may be calculated as follows—

	American.	English.
8 hours' sleep at basal . 16 hours awake (8 at basal and 8 at basal + 30 per cent.) . . .	1,568 Cals.	1,476 Cals.

Taking 1,500 Calories as the resting

metabolism, the total energy requirements come out as follows—

Seamstress . .	1,500 + 43 + 240 = 1,783
" machine (*a*)	1,500 + 173 + 240 = 1,913
" " (*b*)	1,500 + 410 + 240 = 2,150
Laundress (*a*) . .	1,500 + 893 + 240 = 2,633
" (*b*) . .	1,500 + 1,541 + 240 = 3,281
Charwoman (*a*) . .	1,500 + 583 + 240 = 2,323
" (*b*) . .	1,500 + 1,130 + 240 = 2,870
Bookbinder . .	1,500 + 367 + 240 = 2,107
Typist[1] . . .	1,500 + 173 + 240 = 1,913

It would seem that in the case of these occupations, except those of machinist, laundress, and charwoman, a net allowance of 2,400 Calories a day would meet not only the energy expenditure in their trades, but would leave a considerable surplus to represent the work done in connection with the home. If we take, as is usual, a net allowance of 3,000 Calories a day for the working man, it would seem fair to allow 2,400 Calories a day for the working woman, or allowing 10 per cent. difference between food as digested and food as purchased, the food requirements of the working woman should have a Calorie value of 2,650 Calories per

[1] Determined by Carpenter.

diem. On the other hand, for the sedentary individual occupied only in work such as typewriting and free from the heavier duties of the home, the net expenditure of energy in the day would not be more than 1,900 Calories, and the food requirements of such an individual would be amply met by an allowance of 2,100 Calories per day.

The allowance of 2,400 Calories per day for the average woman is probably a safe one, since so large a proportion of women are engaged in sedentary occupation. This allowance amounts to ·8 of the allowance for the adult male, and we shall certainly not err on the wrong side if we adopt the figure given by Lusk for the normal woman's requirements, viz. ·83 that of man.

Food Requirements of Children

Of the 45·2 million inhabitants of the United Kingdom in 1911, over 13 million were children below the age of 14 years. In the determination of the requirements of this section of the population we have very

few reliable data to guide us. The food requirements of the growing animal are determined by—

(1) Basal Metabolism.

(2) Rate of Growth—*i. e.* the amount of food which is not consumed in the body, but is laid on to supply increased weight and height.

(3) Bodily Movements.

In the child the spontaneous and aimless muscular activities of play are not directed, as in the adult man, to the production of useful work; they however play a prominent part in securing the health of the child and in furthering the development of the muscular and nervous systems. The basal metabolism of the child cannot be deduced from that of man by merely taking into account the lessened size and weight. Per square metre of body surface the energy output of a child is considerably larger than that of the adult, as is shown by the following table, which gives the basal heat production per square metre per hour in boys of various ages (Du Bois)—

Mean age.	Number of observations.	Basal heat production per square metre per hour.
6·5	4	57·5 Calories.
12·6	4	50·4 ,,
13·7	4	49·4 ,,
16·5	8	43·0 ,,
19·25	7	40·7 ,,

The data for girls are still more scanty than those for boys, but those that are at our disposal do not warrant us in assuming a lower basal metabolism in girls than boys up to the age of 15.

Greenwood gives the following table (p. 37) of the probable basal needs of boys and girls, calculated according to Du Bois' observations, and the average size and weight of children at different ages.

The fact that growth is proceeding throughout these years implies that excess of food must be taken over that required to furnish the energy output of the body. Between the ages of 11 and 16 both sexes put on weight at the average rate of about 4 kilos. a year. This is equivalent to adding to the body a store of about 800 Calories per month, representing the energy which has been taken in the food and not expended by the body. It

Boys.					Girls.				
Ages.	Weight. (kilos.)	Height. (cm.)	Surface. (sq. m.)	Basal Needs. (Cals.)	Ages.	Weight. (kilos.)	Height. (cm.)	Surface (sq. m.)	Basal Needs. (Cals.)
5	18·09	104·21	·714	1,026	5	17·78	103·00	·703	1,008
6	20·14	111·76	·786	1,100	6	18·91	108·91	·751	1,051
7	22·54	116·76	·851	1,159	7	21·55	112·90	·815	1,110
8	24·90	119·50	·903	1,197	8	23·63	118·36	·878	1,163
9	27·40	126·24	·979	1,262	9	25·17	123·77	·931	1,201
10	30·62	131·67	1·058	1,328	10	28·12	129·66	1·009	1,266
11	32·66	135·81	1·112	1,358	11	30·89	134·87	1·081	1,321
12	34·79	139·67	1·166	1,389	12	34·65	141·37	1·174	1,399
13	37·47	144·55	1·235	1,430	13	39·55	146·73	1·275	1,476
14	41·73	150·70	1·331	1,499	14	43·86	151·89	1·367	1,539

The heights and weights in this table are the averages published in 1883 by the Anthropometric Committee of the British Association, and do not differ sensibly from more recent figures. The weights include clothing, and, owing to variations of costume at different ages, there is no general agreement as to what deduction ought to be made to reduce to net weight. Consequently the computed surfaces, based upon the published weights and heights, are, to an indefinable extent, in excess. The error thus involved is not a very serious one, but the estimates of heat production per square metre per hour are to be accepted with great reserve. To calculate the entries in the table the formula $\log y = 1{\cdot}8362 - 0{\cdot}0118\,x$, has been used, y being the heat production per square metre per hour and x the age in years. This formula was used to smooth the experimental determinations of Du Bois, which were themselves not numerous, and cannot be regarded as anything but an interpolation formula.

must be remembered that the growing body is formed at the expense of many different kinds of food, which have to undergo chemical conversions of various kinds before they can take their place as part of the living body. Thus, although 800 Calories per month represent an addition to the daily ration of only about 30 Calories, the amount of energy required in the food in order to produce this addition of weight is probably considerably higher than 30 Calories.

The most difficult factor to compute is however the energy output due to muscular activity. The few data we have at our disposal, based on the diets at various schools, are so discordant that it is difficult to draw any conclusions from them. The muscular activity of the child is probably an extremely valuable factor and will tend to be in proportion to the amount of food supplied. Any reduction of the amount of food will probably cause a diminution in activity before it affects the processes of the body essential to health and growth. Only in this way can we explain the striking discrepancy between

the diet allowed in some higher class boarding schools for boys and that on which children of the working classes certainly attain satisfactory development. In one American boarding school for boys investigated by Gephart the average diet of boys between 13 and 16 had daily the energy value of 5,000 Calories. Of this 600 Calories were represented by chocolate bought by the boys. There is no doubt that the allowance for children formerly assigned by Atwater was too low but, if we exclude the well-fed and over-exercised schoolboy of the wealthier classes, the values given by Lusk may be accepted as sufficient to secure full health and development in the great mass of the population. In the following table (p. 40) I reproduce the food requirements of children of both sexes at different ages in relation to the food requirements of the average man, as given by Lusk.

It will be seen that from the age of 14 onwards the adolescent is assumed to need as much as the average man or average woman, in spite of the fact that weight and

Age.	Coefficients.	Utilisable Calories.
0–6 (both sexes) . .	0·5	1,500
6–10 " " . .	0·6	1,800
10–14 " " . .	0·83	2,500
14–20 (boys) . .	1·0	3,000
Average man . .	1·0	3,000
14–20 (girls) . . .	0·83	2,500
Average woman . .	0·83	2,500

height are less and that the work done is also probably less.

We are now in a position to calculate the total energy output and the total food requirements of all the inhabitants of the United Kingdom. We will take these first for the years 1909 to 1913. The distribution of the population among the different ages and sexes is shown in the following table (p. 41).

By using the coefficients already decided upon as a result of examination of the average requirements of males and females at different ages, we can determine the 'average man value' of this mixed population.

Adopting Atwater's coefficients, we find that each individual corresponds to ·77 of

POPULATION OF UNITED KINGDOM (1911), AND MAN VALUE.

A. (ATWATER'S COEFFICIENTS).

Ages.	Population.	Man Value per head.	Total Man Value.
0–6 . . .	5,772,153	0·4	2,308,861
6–10 . . .	3,708,513	0·5	1,854,256
10–14 . . .	3,548,403	0·6	2,129,042
14 and 15 Males .	862,203	0·8	689,762
14 and 15 Females .	859,815	0·7	601,870
16 and above Males .	14,574,430	1·0	14,574,430
16 and above Females .	15,948,114	0·8	12,758,491
Totals . .	45,273,631	0·771	34,916,712

B. (LUSK'S COEFFICIENTS).

Ages.	Population.	Man Value per head.	Total Man Value.
0–6 . . .	5,772,153	0·5	2,886,076
6–10 . . .	3,708,513	0·7	2,595,959
10–14 . . .	3,548,403	0·83	2,945,174
Males, 14 and upwards	15,436,633	1·0	15,436,633
Females, 14 and upwards	16,807,929	0·83	13,950,581
Totals . .	45,273,631	0·835	37,814,423

an 'average man,' and, if we adopt the higher coefficients given by Lusk, as has been done by the Inter-allied Scientific Food

Commission, each individual corresponds to ·835 of a 'man.'

The man value of the total population in 1911, using Lusk's coefficients, thus comes out at 37·814 million. Allowing for each of these 3,300 Calories per day, the total requirements of the year for the population of the United Kingdom would be 45,460,239,000,000 Calories, or in round figures 45·5 billion Calories.

It is interesting to note that the Calorie requirements of the average man for the year is something over one million, viz. about 1,200,000 Calories. We can compare this figure, which we have arrived at as the result of our calculations based on the scientific data with regard to food requirements and energy output, with the total amount of food which can be proved to have been actually consumed or been available for consumption in the United Kingdom during the years 1909–1913. This computation is to be found in the First Report of the Royal Society on the Food Supply of the United Kingdom, dated 9th December,

1916 (*v.* Appendix II). In this Report are given the sources of the figures adopted, chiefly compiled by the Board of Trade. The total Calorie value of the food produced in the United Kingdom, and imported from abroad, amounted to 47·146 billion Calories. Of these 16·926 billion Calories resulted from home production and 30·22 billion Calories from importation, so that we were producing in the United Kingdom just over one-third of our total requirements.

This amount, divided up among the total population, gives a daily ration of 3,410 Calories per average man; none too large when it is taken into account that in this figure is included the allowance for losses in food by spoiling in transit, etc. It is true that the computation takes no account of the food grown in gardens and allotments ('cottage produce'), and the farm produce consumed by the producers. According to estimates contained in an Address to the Birmingham meeting of the British Association, 1912, and based on a partial census, these two items may be calculated as furnish-

ing about 200 Calories per average man per day, so that we arrive at a total allowance per man per day before the war of about 3,600 Calories.

When we look back to these times of plenty and consider the high figures for consumption obtained from observations on workers in receipt of good wages and provided with all they required in the matter of food, the margin for wastage—viz. 300 Calories—seems very small. Thus, according to Rowntree, the average consumption per 'man' in the working class, earning over 26*s.* per household, was 3,390 Calories and in the servant-keeping household 3,807 Calories. Returns from various hostels for munition workers during the war gave a Calorie consumption per diem per average man varying from 2,144 to 4,455. In some of these hostels the diet was known to be insufficient, and had to be supplemented by the workers. In one large hostel, where the returns were very detailed and reliable, the average consumption per diem was 3,951 per average man.

It must be remembered however that, according to the statistics by Rowntree and by Booth, 30 per cent. of the population before the war were under-nourished, their wages being insufficient to allow them to buy adequate amounts of food. This is evident from the following table of the food consumption in different categories of the working classes (p. 46).

Indeed the effect of the war, while reducing the over-lavish consumption by the richer classes and leaving the Calorie value of the diet of the well-to-do workman at its pre-war figure, has been to reduce the number of the underpaid and ill-nourished working classes.

The average consumption per 'man' in the United Kingdom has remained practically stationary during the war, and very little, if at all, below that obtaining before the war. Thus, excluding cottage produce, the allowance per 'man' before the war was 3,410, as against 3,357 in 1916–17, and 3,377 in 1917–18 for the civilian population. If we take into account the more active cultivation of allotments and

ENERGY VALUE OF VARIOUS DIETARIES, CALCULATED ON LUSK'S MAN VALUE BASIS.

	Grams per head daily.			Calories daily.	Cereal ratio.	Pounds per head weekly.			Man Value of average household.
	Protein.	Fat.	Carbo-hydrate.			Meat.	Flour.	Sugar.	
Rowntree—									
Class I. Wages under 26*s*.	70·1	75·7	386·1	2,574	49·4	1·93	5·21	1·14	3·65
Class II. " over 26*s*. .	95·6	108·9	484·1	3,390	45·3	2·93	6·23	1·16	4·61
Class III. Servant-keeping .	105·4	151·3	480·1	3,807	29·7	4·09	3·86	1·38	5·26
Board of Trade—									
I. Wages under 25*s*. . .	74·1	50·6	462·3	2,670	61·3	1·35	6·31	·97	3·94
II. " 25*s*. to 30*s*. .	78·9	60·7	485·6	2,879	55·2	1·56	6·45	1·13	4·07
III. " 30*s*. to 35*s*. .	83·9	69·9	498·2	3,036	55·5	1·85	6·41	1·22	4·01
IV. " 35*s*. to 40*s*. .	82·7	73·0	491·7	3,034	54·0	1·90	6·34	1·27	4·14
V. " over 40*s*. . .	89·9	83·1	534·0	3,330	53·3	1·97	6·85	1·40	4·82
British Agricultural Labourers									
Northern Counties . .	74·4	95·5	461·3	3,085	—	—	—	—	4·55
Midland Counties . .	73·9	75·9	453·5	2,868	—	—	—	—	"
Eastern Counties . .	78·0	70·0	503·9	3,037	—	—	—	—	"
Southern and South-western Counties . . .	80·8	70·8	506·7	3,067	—	—	—	—	"

cottage gardens during the last two years, there was probably an actual increase in the average consumption of food in the United Kingdom in spite of the world shortage of food. No greater testimony than these figures could be given to the efficacy of the control of food in this country.

It is interesting to note that in France, where, according to official statistics, the average consumption per 'man' per day before the war was 3,800 Calories, this fell in 1916–17 to 3,300 Calories, and in 1917–18 to 2,900 Calories. Here again it is necessary to add some unknown figure for the cottage and garden production, but this item was probably diminished rather than increased in France, in contradiction to what obtained in the United Kingdom.

The estimates of the requirements and consumption during the war itself had naturally to be on a somewhat different basis to those for the years 1909–1913. The diversion of a large proportion of the adult male population from civilian occupations, often sedentary, to service in the Army,

necessitated an increased allotment of food, and therefore an increased man value of the population. The method of calculating the man value of the population, of which a large proportion of its members are in military service, is shown in the following table (p. 49).

A soldier cannot be regarded as an average man, but must be fed as a hard worker. On this account 3,800 Calories per day are assigned to him, an amount which is inferior to that actually allowed to our soldiers in the field, but which is probably sufficient when all classes of soldiers are taken into account. The actual field ration amounts to something over 4,000 Calories. Laborious direct determinations of the energy output of recruits in training, carried out for the Army Medical Department by Prof. Cathcart, have shown that the needs of this class, mostly young, cannot be satisfied with a daily ration of less than 3,750 Calories; 3,800 Calories, therefore, seems a fair average to allow for all classes of soldiers and sailors, and this figure was adopted by the Inter-allied Scientific Food

MAN VALUE AND ESTIMATED FOOD REQUIREMENTS OF UNITED KINGDOM FOR THE YEAR 1918–19.

	Numbers.	Gross Calories per head per day.	Man Value.	Gross Calories per day (millions).	Fat per day (metric tons)	Total Man Value.
Children, 0–6	5,772,000	1,650	0·5	9,524	216	2,886,000
" 6–10	3,709,000	2,310	0·7	8,568	195	2,596,000
" 10–14	3,548,000	2,750	0·83	9,757	221	2,945,000
Females, 14 and upwards	17,815,000	2,750	0·83	48,991	1,109	14,786,000
Males, 14 and upwards (Civil)	12,156,000	3,300	1·0	40,115	912	12,156,000
Males, 14 and upwards (Forces)	5,000,000	3,800	1·152	19,000	750	5,760,000
TOTAL	48,000,000	"	"	135,955	3,403	41,129,000
OMITTING THE FORCES	43,000,000	"	"	116,955	2,653	35,360,000

'Man Value' of population, including Forces, per person . . 0·86
" " " excluding " " . . 0·82
Calorie requirements per year in million millions: including Forces . 49·6
" " " " " excluding Forces . 42·7

Commission for the Forces of the United Kingdom. For the French Forces the figure 3,700 Calories was taken. The total number of men had to be very roughly assumed, as the exact details of the numbers were not available for publication.

CHAPTER III

INFLUENCE OF A RESTRICTED FOOD SUPPLY UPON A NATION

Most of my audience will remember the interest which was aroused some years ago by the publication of Chittenden's *Physiological Economy in Nutrition.* In this book the author maintained, not only that the amounts of protein contained in the normal diets of Voit and Atwater were excessive and therefore deleterious to health, but also that it was possible to reduce with advantage the number of Calories formerly assumed as necessary to meet the energy production of an ordinary individual during the day.

Chittenden certainly showed that many individuals—and he chose for his experiments squads of soldiers as well as squads of students—could exercise a considerable reduction both in their protein intake and in the Calorie value of their diet, during a

period extending over many months, without any appreciable diminution in either their muscular or their mental activities.

It was objected to Chittenden's conclusions that a physiological minimum was not necessarily a physiological optimum; and that, although his results showed the adaptability of the animal body to changed conditions, they did not show that, given a free choice of food, any advantage was to be gained in a reduction of the food below the quantity dictated by the appetite. All the subjects of his experiments later on returned to a normal way of living, so that apparently the advantages claimed by Chittenden for a restricted diet had not been sufficiently great to counteract its disadvantages or discomforts.

The values we have arrived at for the energy needs of normal individuals are founded on observations on persons in good condition who have been thoroughly well nourished, and the food requirements we have assumed represent those sufficient for maintaining these persons in the same

well-nourished condition. Those who are concerned with the rearing of stock know that the fatter an animal becomes the greater is the amount of food necessary to retain it in this condition. For example, the basal metabolism of a fat ox is at least 50 per cent. higher than that of the same ox before the process of fattening began.

The effects of considerable restriction of diet have been lately investigated with great care by Benedict on a number of young healthy adults. The first effect of diminution of food is a diminution in the weight of the body. The individual, if he remains at his work, puts out at first the same amount of energy as before, the energy lacking from the food being supplied in the first place by the fat and in the second place by the muscular tissues of the body. But when under this regime the weight has fallen by 10 to 12 per cent., the basal requirements of the individual are found to be largely reduced. Thus, in one case where a man 5 ft. 2 in. on semi-starvation diminished in weight from 115 lbs. to 84 lbs.,

his basal metabolism was diminished from 40·5 to 33 Calories per square metre of body surface per hour. In another case, in a man 6 ft. 2 in., where the loss of weight was still larger—viz. 163 lbs. to 101 lbs.—there was a diminution of basal metabolism from 40 to 25·4 Calories per square metre body surface. Under these conditions all the processes of the body are carried out more economically. There is no diminution in the actual expenditure of energy required for doing a certain amount of work; but the basal metabolism is diminished and the individual is more economical in effort and economises his muscular activity to the utmost possible extent. Thus, in a squad of men investigated by Benedict the normal demand of the men for food ranged from 3,200 to 3,600 net Calories. After a loss of 12 per cent. in the body weight had been reached, they were able to maintain this weight and to carry out their normal work on a diet of 2,300 Calories—*i. e.* a diminution of one-third in their previous food requirements.

During the war a similar experiment has been made on a vast scale in Germany, where the urban inhabitants were compelled from 1915 onwards to live on a daily allowance of food equivalent to no more than 2,300 Calories per average man. The results of this prolonged restriction of diet have only recently been made public. In their First Report, the Royal Society Food (War) Committee pointed out that such a restriction of diet would necessarily occur in Germany, and added that the enforcement of further and closer restrictions, by means of the blockade, could be expected to hasten the breakdown of military power in the German Empire. The results seem to have been as might be expected from laboratory experiment. All the inhabitants lost weight; though at first, at any rate, they were able to carry out their ordinary work under the stress of circumstances in which they were placed. A supplementary ration had however to be supplied to the heavy workers, since the diminution of weight and of the basal metabolism does not decrease the amount of

chemical change necessary for the performance of mechanical work. But as early as 1916, the results of this continued under-feeding, in which the poorer members of the population received only from one-half to two-thirds of the amount which we consider adequate, were making themselves felt, and attention was drawn to them by physiologists and medical men in Germany, though their publication was originally suppressed by the censorship.

Since the autumn of 1916, the daily allowance of rationed food in Germany has amounted only to 1,500 Calories per head (about 1,800 Calories per average man). All the principal foods were rationed, so it was possible to obtain only 200 to 300 Calories extra in the shape of unrationed foods (chiefly green vegetables). The protein and fat were reduced in still greater proportion, the average daily amounts per head being—

Protein	30–40 grams.
Fat	10–20 „

The results on the poorer members of the lower and middle classes (*i. e.* all those who

could not afford to pay ten times the maximal price for foods smuggled from the farms and traded illicitly) have been disastrous.

Among these results may be mentioned the great increase in mortality, especially among children and those in the later stages of life, due to lessened power of resistance against infectious disease, above all tubercle. It has been calculated that during the four years of war these causes led to an excess mortality of 760,000 persons, and in December last it was calculated that 800 persons more were dying daily than had been the case during the last few years before the war.

The birth rate was diminished, the nourishment of babies at the breast deficient, and the mortality of children between one and five years of age doubled. The children that survived, although not much affected in their growth in length, were under-weight and anæmic, and the excess physiological activities of the child, which have their outlet in play and games and are so important for its normal development, entirely ceased. The output of the workman diminished

steadily, owing to the loss both of mental and of bodily powers. Rubner remarks that the emaciated human body is certainly a bad machine. Nor was there much difference in efficiency between mental and manual workers. One writer says, "Under present conditions, every spirit of enterprise, every initiative, every elevation of thought, is reduced into non-productive depression."

These conditions, when they affect a whole nation to such a degree of intensity, naturally attract the attention of the whole civilized world. But they should also serve to impress upon us the evil economic effects on the productivity and health of the nation as a whole, which must result so long as we allow so large a percentage of our population, as was the case before the war, to live in a state of permanent under-nutrition. The figures given by Rowntree with reference to the mortality and the incidence of disease among the poorer classes of the population, amounting to nearly 30 per cent. of the whole, bear out fully the lessons taught by the effect of the blockade in Germany.

Rowntree gives the following figures of the death rate among the different classes of the population of York—

Area No. 1 (poorest), 27·782 deaths per annum per 1,000 of population.
Area No. 2 (middle), 20·712 deaths per annum per 1,000 of population.
Area No. 3, (highest) 13·49 deaths per annum per 1,000 of population.
Whole of York, 18·53 deaths per annum per 1,000 of population.

Thus the mortality amongst the very poor is almost twice as high as amongst the best paid sections of the working classes. It must be remembered too that a high death rate implies a low standard of general health and therewith general impairment of efficiency, without speaking of the sickness and suffering incident thereto.

A nation, which has been able to provide for its members with such brilliant success during a European war and a submarine blockade, should be able to prevent a recurrence of these peace-time conditions, which must be regarded as a slur on our civilisation and a waste of our national resources.

CHAPTER IV

COMPOSITION OF THE FOOD

So far we have dealt only with the total Calorie requirements of a nation. So long as means to purchase are available and exchange of products unfettered, the natural instincts or appetites of man, combined with the ordinary laws of supply and demand, may generally be trusted to result in a proper apportionment of these Calories among the different classes of foodstuffs. But in times of national stress there may be a shortage, for one reason or another, of some or many of the ordinary articles of food, so that it becomes important to know within what limits the ordinarily accepted quantities of the foodstuffs can be varied without detriment to health and efficiency.

The constitution of a normal diet has been given somewhat differently by various

authorities. Voit gives three diets as follows—

	Average Man.	Soldier (manœuvres).	Soldier (war-time).
Protein	118 grams	135 grams	145 grams
Fat	56 „	80 „	100 „
Carbohydrates	500 „	500 „	500 „
Calories	3,055 „	3,348 „	3,575 „

The Royal Society Food (War) Committee adopted the following as the diet of the average man—

Protein	100 grams
Fat	100 „
Carbohydrates	500 „

Total Calories, 3,390.

These dietaries are based on the average composition of actual diets. It is more important to know how far the different foodstuffs are interchangeable among one another, and what is the minimum to which any given foodstuff can be reduced without untoward effects or even inconvenience.

Protein.—As regards protein, numerous researches have shown that this substance *can*

be reduced far below the amount at present in the average diet. Of the protein taken in the food, a certain proportion is necessary for making good the wear and tear of the tissues of the body. For this purpose between 30 and 40 grams a day would probably suffice, *provided that the protein is of a proper constitution.* This saving clause is extremely important. There is a wide divergence in the composition of different proteins. Vegetable proteins differ considerably in composition from animal proteins, and these in their turn are variously constituted according to the organ or part of the body from which they are derived.

In the process of digestion the protein molecule is dissociated into its constituent amino-acids. These are absorbed into the blood, and each cell takes out such amino-acids, and in such proportions, as are necessary for its re-integration. All the amino-acids, which are not required for repairing waste or for building up the body, lose their nitrogen, which is excreted as urea in the urine, and are then burnt up to furnish energy for the

body. It is evident then that, to supply a certain loss of body protein, a larger amount of vegetable protein will be necessary than of animal protein such as that of meat or of milk, since some of the amino-acids are present in the vegetable protein in a larger amount than is required to build up animal protein. The excess will be simply burnt up and serve to furnish energy to the body.

Thus we cannot assume that the minimum requirements of protein, as ascertained by experiment, apply to all kinds of protein or even to the total proteins present in a mixed diet. The minimum amount of the most suitable protein required by the average man per day being 35 to 40 grams, it is advisable to double this figure and to assume 80 grams as the minimum quantity which should be provided in a mixed diet. It should also be laid down that a portion at any rate of this protein should be of animal origin.

In most cases we find that, if the Calorie value of a mixed diet is adequate, this diet will contain more than 80 grams of protein, and indeed over 100 grams. In view of the

great preponderance of vegetable food in the food of the poorer classes, the Royal Society has laid down 100 grams as the minimum amount of protein which should be aimed at. Even with this higher figure there will be in most cases very little need to trouble about this provision if only a sufficient number of Calories are provided. Bayliss's dictum, "Take care of the Calories and the proteins will take care of themselves," well expresses this fact. In most cases therefore, the provision of protein need not form the subject of special care to the State. In Germany during the war there was certainly a deficiency of protein in the diet, but this was associated, we have already seen, with dangerous diminution of the total Calorie value of the foodstuffs, and was only exacerbated by the shortage in foods of animal origin.

Carbohydrates and Fats.—Since both these foodstuffs play only a small part in the building up of animal tissues, and serve almost exclusively as sources of energy in the body, and since moreover carbohydrates can be

converted in the body into fats and indeed serve as the chief source of the fat formed in the fattening of animals, it might be thought to be a matter of indifference whether the total Calories necessary, after provision of the proper amount of protein, were obtained exclusively either from fats or from carbohydrates. Within wide limits, one of these can replace the other in isodynamic proportion. Since a gram of carbohydrates on oxidation in the body gives rise to 4·1 Calories, and a gram of fat to 9·3, 4·1 grams of fat can be replaced in the food by 9·3 grams of carbohydrates.

But this property of mutual replacement is limited. It has long been known that it is not possible, without deleterious effects, to replace the whole of the carbohydrates in the diet by fats. Such a procedure leads to an excessive breakdown of proteins in the body and to deficient oxidation of the fat, so that poisoning results from the accumulation of the intermediate products of fat oxidation.

The necessity for a minimum amount of carbohydrates is not however important in

the victualling of a nation, since this class of foodstuffs is the cheapest and most easily obtained source of energy to the body, forming as it does the chief constituent of nearly all vegetable foods.

On the other hand, the provision of a sufficient amount of fat has proved during the war to be, in practice, one of the most difficult problems which faced the different belligerent nations. The lack of this substance has been the greatest affliction of the people in Germany, and a deficient supply of fat in this country over several months represented the only occasion on which food shortage caused serious inconvenience to our people during the war. According to Hindhede, it is possible to maintain a working man in health and efficiency on a diet almost free from fat. In his experiments the total Calorie value of the food was very large, and the only shortage had reference to fat. The results obtained might be anticipated from the well-ascertained fact that the body itself is able to manufacture fat out of the carbohydrates supplied to it.

But in the practical rationing of a nation, it is found that fat is an essential constituent of the diet, and the provision of a sufficient quantity must be always one of the most serious pre-occupations of the authorities of a State who are making themselves responsible for the feeding of their population. Although the absolute physiological need of the cells of the body for fat, given as such in the food, is not proved, we cannot regard laboratory experiments of short duration as sufficient to decide the question whether fat is necessary in the ration or not. So great are the powers of adaptation in the animal body that it is able to resist for a considerable time unfavourable conditions, and it is only when these are continued for months or years that the full deleterious effects become apparent.

The significance of fat in the diet depends on several factors. In the first place, fat is highly assimilable and is almost entirely absorbed from the alimentary canal. But it is digested and absorbed more slowly than carbohydrate. Whereas the greater part of the latter is absorbed three hours after food

has been taken, the most intense absorption of fat occurs between five and six hours after a meal. On this account a meal lacking in fat is deficient in staying-power. Man is unaccustomed to working with the alimentary canal entirely at rest. When digestion of the last meal is finished hunger recurs and affects the efficiency of work. Thus Major Ewing relates how on a railway job in Canada the Italian workmen were found to become inefficient at about 11 o'clock in the morning These workmen were spending only 7 to 8 dollars for food at the canteen as against 15 dollars expended by the Canadian workmen. The chief difference in the diet conditioned by this economy was in the meat. The company then insisted on the Italians spending 15 dollars a month. With the extra money they bought fat beef, and it was then found that their work was entirely satisfactory. It may be objected that in this case it was the lean of meat—that is, the extra protein rather than the fat—which was responsible for the difference; but examination of the dietaries of very heavy workers—for example,

lumbermen in Sweden and in Canada, who were consuming food with a Calorie value of 4,000 to 8,000 Calories a day—shows that this great increase in food related not to the protein but to the fat. The Canadian lumbermen live largely on fat pork and beans. In this country, too, there were complaints from the Welsh miners during 1918 that the food did not enable them to work their normal shifts. They are used to taking with them to their work pies made of fat pastry with a little meat, and it was impossible to make the pastry in consequence of the absence of fat. Premature hunger was also a universal experience in this country during the first five months of last year.

In the second place, the bulk of food must be of considerable importance, especially when the total food required to supply the energy needs of the body is very large. Weight for weight fat has more than double the Calorie value of starch and sugar. But the difference in bulk is still greater, since fat is taken without admixture in a pure form, whereas the other foods are all mixed with a

considerable proportion of water. The proteins in meat form only 15 to 20 per cent. of the total bulk. Starch cannot be taken except mixed with large quantities of saliva. When ordinarily cooked it is swollen up with probably five to ten times its amount of water. Even after absorption the same necessity for increasing the bulk of carbohydrates with water persists. Thus glycogen, the form in which starch is stored up in animals, does not occur in the liver to a larger amount than 12 per cent., whereas we may find as much as 30 per cent. of fat in this organ, and adipose tissue may contain as much as 80 per cent. of fat. When carbohydrate goes into the circulation it is changed into sugar, and as sugar it needs twenty times its weight of water to carry it. It acts therefore to some extent in the same way as common salt. Just as an extensive diet of salt may produce dropsy, so a diet of carbohydrate increases in the first place the water content of the body, and this factor, when associated with inanition and fat shortage, may itself produce actual dropsy.

The question of bulk is probably one of the most important factors in determining the need for fat. The human alimentary canal (at any rate, in our race) has been developed so as to cope with a diet in which 20 to 25 per cent. of the energy is presented in the form of fat. In order to get the same energy from carbohydrates the alimentary canal would have to be much larger. Theoretically the absence of fat can be made up by an increased supply of carbohydrates. But this can only be carried out in a certain number of individuals and under certain conditions. The ordinary individual deprived of fat diminishes his total intake of food and exists on a lower metabolic level. It is a notable fact that during the shortage of fat in this country in the early part of 1918 there was no appreciable increase in the consumption of cereals. It was easier to live on the stored-up fat of the body than to adopt a stuffing process with carbohydrates.

In the third place, it seems that carbohydrates are more subject to fermentative changes in the intestines than fats. Over-

loading the intestines with carbohydrates in many individuals leads to abnormal fermentation, the production of gases, and general discomfort. We may conclude then that fat is an essential ingredient of the diet of man, and that there must be some relation between the quantity of fat necessary and the total energy requirements of the individual.

This relation must be founded on a statistical inquiry, *i.e.* by studying the proportion of fat to the whole diet taken by a number of individuals of different energy requirements. It must be owned that such a method can give us no information as to the minimum fat requirements, nor can we assert that the average fat ration is the optimum one, but it will serve to guide us as to the minimum desirable ration in the different races from which the statistics are taken. This quantity certainly differs considerably among different races, so that dietetic habit plays a considerable part in its determination. Thus it is larger in the northern than in the southern races. The

Japanese soldier is content with 20 grams of fat daily, and satisfies 80 per cent. of his food needs with rice. The Italian labourer in his home takes probably less than 60 grams of fat per day. On the other hand, the child at the breast takes 50 per cent. of its nourishment, measured in Calories, in the form of fat.

In a series of diets given by Tigerstedt and by Atwater for individuals of different occupations, the proportion of fat Calories to total Calories varied from 18·4 per cent. in an obviously insufficient diet to 39·7 per cent. If we take into account only those diets which were certainly adequate, we may say that one quarter of the total Calories of the average diet should be in the form of fat, including in this amount, not only the fat contained in meat and butter, but also the small proportions of fat hidden away in other foods such as cereals. On this ratio, the normal diet of the average man, with a Calorie value of 3,300, should contain 75 grams of fat per day. The proportion of fat to the total diet

may be increased to 35 per cent. without harm or perhaps with advantage, since where an abundance of animal food is available, as in America, the average amount of fat taken approaches this figure: and the fat ration should always be high if there is a large increase in the energy expenditure of the body, either in the form of work or in consequence of exposure to cold.

It is immaterial whether the fat be derived from vegetable or animal sources, if it be borne in mind that the fat of meat and of milk contains valuable accessory substances essential to growth, so that in the case of a purely vegetable fat diet—*e.g.* margarine made from vegetable fats—these accessory substances must be provided in other ways. But a plentiful supply of vegetable fats is obtainable only in the warmer parts of the globe, so that their adequate provision depends on a command of sea-borne trade.

Accessory Food Substances (*Vitamines*). It has long been known that prolonged abstention from fresh food may cause

deterioration of health and outbreaks of Scurvy ; and recent investigation has shown that, in addition to the main classes of food-stuffs, most fresh foods contain minute quantities of substances whose chemical composition is unknown, but which are essential to the maintenance of health and growth.

Of these accessory food substances three classes have been distinguished, viz.—

(1) A water-soluble substance, present in oranges, lemons, fresh green vegetables, in roots and tubers, in small quantities in fresh meat and milk, the absence of which causes Scurvy.

(2) A second class present in the husks of rice and in grains, in yeast and in eggs, in the absence of which Beri-Beri may develop.

(3) A fat-soluble group present in the fats of milk and of fresh meat, and possibly also in green vegetables, which are essential if growth is to be normally carried out.

These substances are destroyed by prolonged heating as in cooking or stewing, by

drying, and by various other manipulations. Thus precautions taken by a government to prevent future shortage of food by making a store of food in a non-perishable form (canned or salt meats, dried vegetables, etc.) might lead to a deterioration of the general health, and even to actual outbreaks of Scurvy and Beri-Beri. It is important therefore that artificially prepared foods should not be allowed to constitute too large a proportion of the whole diet. Examples of such foods are white bread, polished rice, the majority of patent breakfast foods, preserved meats and vegetables, dried fruits. No diet will be satisfactory unless it contains a certain amount of fresh fruits or green vegetables. In these days, when margarine, artificially prepared from vegetable fats, forms so important an item in the diet, it becomes more than ever essential that milk or milk fat should be provided for children. Not only is the protein of milk better fitted by its digestibility and its composition for assimilation by the child, and the building up of its body, but the fat of milk is richer than

any other food in the fat-soluble accessory substances essential to growth.

We see then that, with the provision of the necessary Calories, the work of provisioning a nation is only half done. The three main preoccupations of the controlling authority, after providing these Calories, will be the maintenance of a minimum fat supply, the safeguarding of the supplies of milk for children, and the production and distribution of fresh vegetable food.

Only by taking all these points into consideration can the health and efficiency of all classes and ages of the nation be assured.

CHAPTER V

THE PROVISION OF FOOD

In dealing with the provision of food to meet the requirements of a nation, the problem will be different according as we are dealing with a country that is self-contained (*i. e.* one which produces normally sufficient or more than sufficient for its inhabitants), or with a country such as the United Kingdom which is dependent for the larger part of its supplies on importation from abroad. There are certain principles however which are common to both cases.

The food of man is composed almost entirely of the products of the soil, the harvest from the sea forming but a small proportion of the total food, even of a maritime country such as England. The most important crops, regarded as human food, are the cereals—wheat, barley, oats,

etc., and the root crops and tubers, such as potatoes, turnips, etc. Green vegetables and fresh fruits are also an important item, although not contributing largely to the total Calorie requirements.

With these direct products of the soil life can be sustained; but the diet so supplied, at any rate in temperate climates, would not be in any respect an ideal one, or fitted for producing the maximum efficiency in a population. It would be very deficient in fat, and the protein content would be low. This is shown if we examine the percentage composition of wheat, flour, oatmeal and potatoes. The deficit in fat might be supplied by means of oil-seeds, but these form only a small part of the crops which grow readily in temperate climates, so that, unless they can be introduced by importation, there will be a serious deficiency of fats in the diet.

For this reason the inhabitants of Europe have been accustomed to employ animals as a means of converting the vegetable food, rich in carbohydrates, into a food in the form of milk or meat, which is rich in proteins

and in fats. This conversion is partly at the expense of food which might otherwise be used for the nourishment of man (*e.g.* cereals, potatoes, roots, etc.), partly at the expense of crops which man cannot utilise (*e.g.* grass and meadow hay). In this conversion there is a large sacrifice of the energy value of the food. The following table by Prof. T. B. Wood shows the relative economy of different animals as food producers—

Name of Animal.	Kind of human food produced.	Lbs. dry fodder consumed per lb. dry human food produced.	Kind of fodder consumed.
Cow .	Milk, veal and beef	12	Chiefly grass, roots and hay
Pig .	Pork, bacon, ham, etc.	12	Chiefly meal made from grain
Fowl .	Eggs and flesh .	14	Chiefly grain
Sheep.	Mutton (and wool)	24	Chiefly grass, roots, and hay
Steer .	Beef . . .	64	Chiefly grass, roots, hay and straw.

It will be seen that the most economic animals as converters are the cow, pig and fowl. The cow however presents a distinct advantage in that it lives chiefly on grass,

coarse roots and hay, whereas the pig and fowl are nourished largely on grain which could otherwise be employed for human food. A small number of pigs and fowls can however be reared on spoilt grain and kitchen refuse, and what they can pick up in the fields and woods.

According to this table, prime beef is the most extravagant of all forms of animal food, so far as regards the quantity of vegetable food required to produce it. But, as Wood points out, this extravagance is largely due to the fact that, of the 8 tons of dry food which a three-year-old steer would have eaten by the time it is ready for the butcher, about 5 tons will have been used up in simply keeping the animal alive—*i. e.* in maintenance. Thus a considerable economy might be effected by the use of early maturing breeds, which could be killed at 18 months instead of at 3 years. According to Wood, such a steer would produce 1 lb. of dry human food from about 30 to 35 lbs. dry fodder, and calves slaughtered for veal would be still more economical.

It must be owned however that such a method would reduce the total amount of fat available, and we have already seen that the necessity of providing fat is one of the chief physiological justifications for the use of animals for the production of human food.

In an agricultural country under primitive conditions, it is thus hard necessity which determines that the inhabitants are largely vegetarian, satisfying the greater part of their Calorie needs at the expense of bread. Cattle or horses are essential inmates of every farm, but under these conditions they are important as machines for the tilling of the soil, and in this capacity they must share with the human cultivator the crops produced from their joint labours. By the slaughter of these animals, when they are past work, a certain amount of meat is provided. The chief animal food is in the form of milk, cheese and butter, while bacon and veal form the chief meat diet, but figure only to a small extent in the dietary.

With increase in prosperity the part played by animal foods, and specially by the flesh

of animals, becomes steadily more prominent. This prosperity may be occasioned by an increase of land taken into cultivation out of proportion to the number of inhabitants, its working being rendered possible by the invention and production of agricultural machinery, so that one man can do the work of six or ten. It may also be due to better cultivation, increasing the yield per acre. This again is favoured by the employment of agricultural machinery and by the application of artificial manures. Or lastly it may be due to an increasing industrial production, rendering it possible for the nation to exchange its industrial products for food, vegetable or animal, from foreign countries.

By any of these ways the nation acquires an amount of vegetable food considerably greater than its needs, and it has therefore a large excess which it may feed to animals for the production of meat and milk.

Germany

These principles are well illustrated by the present conditions in Germany.

The rapid increase of the population in Germany from 48 million in 1888 to 67 million in 1913 was accompanied by a more than corresponding growth in the wealth of the country, due largely to the appreciation by the nation as a whole of the value of science and to the exploitation, in commerce and industry, of all the scientific knowledge gained during the last half century for augmenting the wealth of the community.

The effect of the application of science to agriculture in a country, whose soil is inferior to that of Great Britain, is well shown by the following striking series of comparisons drawn by Sir Thomas Middleton between conditions before the war in the two countries.

On each hundred acres of cultivated land—

1. The British farmer feeds from 45 to 50 persons.
   „ German „ „ „ 70 „ 75 „
2. The British farmer grows 15 tons of corn.
   „ German „ „ 33 „ „
3. The British farmer grows 11 tons of potatoes.
   „ German „ „ 55 „ „
4. The British farmer produces 4 tons of meat.
   „ German „ „ 4½ „ „

5. The British	farmer produces	17½	tons of milk.
,, German	,, ,,	28	,, ,,
6. The British	farmer produces	a negligible quantity of sugar.	
,, German	,, ,,	2¾	tons of sugar.

These results have been obtained in Germany by improvement in methods of cultivation, so that the total yield of cereals and potatoes during 1909–13 was about twice as great as it had been thirty years previously. It thus came about that, in spite of continuous improvement in the quality of the food consumed by the Germans, as shown by the consumption of meat and the number of pigs kept, the country remained very nearly self-supporting, deriving only 15 per cent. of its total Calories from imports.

The rise of the annual meat consumption in Germany per head of the population is shown in the following table:—

1816	13·6 kilos
1840	21·6 ,,
1883	29·3 ,,
1907	46·2 ,,

It is noteworthy however that a much larger proportion of the total fats consumed

in Germany were derived from importation. Of the average consumption of fats in peace time of about 3 million tons (of which $2\frac{1}{2}$ million were used in the form of food), nearly one-half was imported. Under these conditions it is interesting to inquire what should have been the food production policy of Germany, when reduced by blockade to the position of a country which had to satisfy from its own resources the whole of its food requirements.

It is impossible to read accounts of the German economic conditions during the war without acquiring the impression that, in spite of the respect in which science was held in Germany and the large employment of expert advisers by the Government, either the physiological aspects of the projected war had been disregarded, or, if the experts had been consulted, they had failed to look at the subject from the standpoint of the nation rather than of the individual.

It is true that military reasons had always figured largely among those adduced for the consistent support of agriculture, but this was

chiefly in order that the State might have at its disposal a number of healthy docile men as soldiers. It does not seem that the broad aspects of the question—the problem of making the production of food in the country equal to the necessary minimum consumption—had ever been really faced.

When at last physiologists with economists got to work in the production of the Eltzbacher statement, they had to make the best of the conditions as they found them, and I am inclined to think it was partly on this account that they put such a low value on the food requirements of the country as a whole. Thus, after showing that, with the feeding as in pre-war conditions, the German nation would consume 90·4 billion Calories in the year, including 2·3 million tons of protein, they stated that the physiological requirements would only be 56·7 billion Calories, with 1·6 million tons of protein, so that the population were over-eating to the extent of 59·7 per cent. Calories and 44 per cent. in protein. This is much too large a margin to be accounted for by waste, so that

the statement amounts to a charge of gluttony against the whole nation.

The Royal Society Committee rightly pointed out the inadequate character of the allowance made by the German authorities, and concluded that the German production, even adopting the measures recommended by the Eltzbacher Committee, would supply only 83 per cent. of the total protein needs of the population. As regards Calories, the Royal Society Committee were of opinion that German expenditure could be met by her home production owing to the relatively large resources of potatoes and beetroot, but pointed out that her home production of bread-corn was insufficient for her needs.

The Eltzbacher Committee laid little stress upon the considerable fat shortage which must ensue when 42 per cent. of the total consumption was cut off by prevention of imports, since they regarded the fat as replaceable to any degree by carbohydrates. Though the Royal Society pointed out the great shortage that would occur in the fat supplies, they also, as it seems from our later

knowledge, hardly attached sufficient importance to this item. As a matter of fact, the conditions in Germany in the course of the war became much worse than anticipated by the Eltzbacher Committee, and even worse than those predicted by the Royal Society Committee.

It is interesting to consider what measures should have been taken by the Germans, under the conditions in which they were placed, in order that they might hold out during a prolonged war. We have here a nation suddenly reduced to four-fifths of its previous supply of food. At the same time there is a withdrawal of labour from the production of food, partly for the Army, partly for work on munitions. In any diminution of food the fighting army can take no share, and it is almost equally important that those engaged in the manufacture of munitions should be adequately nourished if their output is to keep pace with the requirements.

The problem therefore resolves itself into the means by which the food available for man can be increased. This may be attained

in the first place by alterations in the system of cultivation—*i.e.* by altering the crops grown on the soil. It has been shown that in the pre-war period, whereas the grass of the United Kingdom supported about 20 persons per 100 acres, about 84 persons derived their food from each 100 acres under the plough. To a certain extent then, an increased food production can be obtained by ploughing up grass land. It is not profitable however to plough up all kinds of grass land. This policy may be impossible in the presence of lack of labour and of working animals. But considerable latitude is possible in the variation of the crops grown as regards their food value. As Middleton has pointed out, the number of persons, who could be supplied with food energy for one year from the produce of 100 acres of average crop grown in the United Kingdom, would be as follows—

Potatoes	450	persons.
Wheat converted into bread, offals into meat	200	„
Mangolds converted into meat	35	„
Meadow hay converted into meat	15	„

Though it must be borne in mind that a certain rotation of crops is necessary for successful farming, these figures bring out the extravagance of producing animal food as compared with vegetable food such as wheat and potatoes.

This comparison leads us directly to the conclusion that in times of scarcity, so far as possible, the total resources of the country must be directed to the production of vegetable food for man, and that the production of animal food must be restricted to the narrowest limits compatible with adequate alimentation. In all cases the consumption of meat, and probably of fats, has increased in proportion to the prosperity of the country. In times of penury it would seem obvious therefore that there should be a return to the conditions of more primitive and less prosperous times, when animal products formed a much smaller proportion of the total food of man.

If land used for growing crops for feeding animals, such as mangolds and hay, be applied to the growth of crops suitable for consumption directly by man, the food

available for animals will be diminished. This diminution of fodder in Germany was largely augmented by the fact that a considerable proportion of the concentrated foods used before the war were imported. The Berlin Committee calculated that about 45 per cent. of the proteins and Calories in the animal food were derived from imported fodder. Moreover, of the food suitable for human consumption, a large amount was fed to animals; thus wheat was milled to about 67 per cent. so as to produce pure white flour, the remaining 33 per cent. of offals being given to animals as concentrated feeding-stuffs. All the oats and the greater part of the barley were also used as feeding stuffs, pigs being fed almost exclusively on the cereal products together with the skimmed milk resulting from butter manufacture. In times of scarcity all these cereals could be used as human food, with the exception of about 15 per cent. of the wheat and 20 per cent. of the barley and oats, which would be too indigestible and would have to continue to be fed as bran to animals.

If therefore all these measures were taken for the increase of the food to man, there would be a very large decrease in the concentrated foods available for animals. It would seem however that sufficient food could be provided for man at the expense of the animals. But there is a limit to this transference of food from animals to man. In the first place, animals—horses and working oxen, are essential for the tilling of the soil. If crops are to be grown, the working animals must share with man the produce of the soil. It will not profit the man to starve the animal, since work, whether by man or beast, represents the product of conversion of food. In the second place, we have seen that a certain amount of fat is necessary in the diet. A country entirely cut off from importation of oil-seeds and vegetable fats from warmer climates must employ animals as its means of production of fats, and for this purpose must set apart a certain proportion of the available food supplies.

In the table quoted on page 80 it is shown

that, as regards conversion of vegetable food into animal food—*i. e.* protein and fat,—the cow is by far the most economical transformer, since it can employ as its raw material feeding stuffs, such as grass and hay, which could not be utilised for human food. Moreover, the milk produced by the cow is essential for the proper maintenance and growth of children. Sheep and goats, which feed on upland pastures and poor land, can also be retained. Pigs on the other hand, which had attained such an enormous development in Germany, are direct competitors with man for food; and, as they produce only one part of human food for every five parts they consume, they are too expensive to be kept in times of penury, except in such small numbers as can be nourished in the woods and on waste. A drastic reduction of live stock would therefore seem to be indicated, with a corresponding diminution in the proportion of the animal food taken by man.

A German author, Oetelshofen, has put the matter very simply. He says—

"If a sufficient increase cannot be effected

by these means, because the food of animals has been composed largely of grass and hay which are not suitable for human food, then part of the meadow-land should be converted into plough-land, so that the requisite vegetable Calories may be secured for human nourishment by more extensive cultivation of corn and potatoes. In any case it is a completely mistaken policy, when the general vegetable basis of the food supply has undergone contraction, to reduce the direct human consumption of vegetable foodstuffs for the sake of producing animal foodstuffs. If a workman, finding that the total vegetable Calories, available for his direct consumption and for conversion into animal food, is reduced from 7,000 to 5,600, seeks to diminish his consumption of vegetable Calories from 2,000 to 1,000 in order that he may have 4,600 Calories for conversion into animal food, he will obtain from such conversion only 920 Calories, and his total daily food supply will therefore amount to 1,920 Calories. This is absolutely insufficient, and he will not be

able to continue his daily work without using up his physical capital, losing heavily in weight, and eventually failing in health. On the other hand, by raising his direct consumption of vegetable food to 2,500 Calories per day, he will be able to obtain the same number of Calories as before, and even a little more. But this method of course can be effectively applied only if the cattle stocks of the country are reduced to such an amount as can be properly fed with the diminished supply of fodder. Otherwise the vegetable Calories used for fodder will be partly or wholly wasted, instead of undergoing conversion into their full equivalent in animal Calories."

It is evident that an attempt to keep the total head of stock alive on the reduced supplies of fodder can result only in disaster. An animal, like man, requires a certain amount of food to keep him alive, neither gaining nor losing weight. This is the maintenance ration. If the animal is to do work, it must be given a corresponding increase in its fodder, and for this purpose

concentrated foodstuffs, for which the animal competes with man, are required. In the same way, if the animal is to be fattened so as to make it fit for human food, and to produce meat containing sufficient of the valuable fat, it must receive an excess over its maintenance ration. Here again the food to be laid on as fat must be of good quality, and generally include some concentrated foods.

Thus, we may imagine that a farmer has sufficient grass and fine fodder to fatten 1,000 beasts. If his total stock amounts to 1,500, and he endeavours to keep them all alive, the food available will provide supplies only for this purpose, and none of the animals will put on fat or produce meat. We thus arrive at the conclusion that, if he maintains his 1,500 animals, he will have no fat and only lean animals to kill, whereas, if he sacrifices at the outset 500 animals, he will be able to fatten the whole remaining 1,000 beasts.

Oetelshofen gives the following illustration of this relation between feeding-stuffs and head of stock—

"Suppose there are two families, A and B, which are exactly similar in circumstances, but pursue opposite food policies during the war. Each of these families consists of five members, and possesses a plot of land which yields annually 25 cwt. of bread-corn and 70 cwt. of potatoes; each family keeps a goat which lives on grass, hay, and kitchen waste, together with two pigs every year, which are brought each to a slaughter weight of 300 lbs. The corn and potatoes grown by each family are not by themselves sufficient for the feeding of the family and the fattening of the pigs, and each family, therefore, has to buy 5 cwt. of bread-corn and 15 cwt. of potatoes every year; so that altogether each family has 30 cwt. of bread-corn and 85 cwt. of potatoes at its disposal. Each family consumes 15 cwt. of bread-corn and 25 cwt. of potatoes directly, and uses the remaining 15 cwt. of corn and 60 cwt. of potatoes for the fattening of the two pigs to a slaughter weight of 300 lbs.

"The outbreak of war makes the purchase of corn and potatoes impossible, and each family is compelled to rely exclusively upon its own production of 25 cwt. of corn and 70 cwt. of potatoes. Family A resolves to keep only one pig; this one pig is fed as in time of peace with 7½ cwt. of corn and 30 cwt. of potatoes, and brought in this way to a slaughter weight of 300 lbs. as before. For its own direct consumption family A has therefore 17½ cwt. of corn instead of 15 cwt. as previously, and 40 cwt. of potatoes instead of 25 cwt. These quantities are more than sufficient, so that a part of them can be supplied as additional fodder to the pig, which is thereby further fattened to a slaughter weight of 350 lbs. Family A by this method secures a more ample supply of vegetable food than in time of peace, together with an adequate, though diminished, supply of animal food.

"Family B pursues an opposite policy. It resolves to maintain two pigs as in time of peace, and to divide the deficiency of 20 per cent. equally between men and cattle. The hard-working members of the family lose

weight, and the pigs do not grow fat. The fodder supplied to them is wasted for the most part in their mere maintenance, and they put on very little meat. When the fattening period is over and the appointed supply of fodder completely consumed, it is found that the slaughter weight of each pig is only 150 lbs. Family B, therefore, has only 300 lbs. of meat as against 350 lbs. secured by family A; and, moreover, the quality of this meat is very much inferior to the quality of that secured by family A. One kilo of lean meat yields only 1,000–1,500 Calories, whereas 1 kilo of fat pork yields 4,500, and pork fat ('Speck') as much as 7,000 Calories per kilo. The single pig maintained by family A has therefore at least three times as much nutritive value as the two pigs maintained by family B.

"The father of family B does not perceive that his policy has been radically wrong. Disputes have arisen in the family because the housewife has occasionally given a handful more potatoes to the hungry pigs or a handful more bread to the hungry sons than was provided for in the scheme of rationing. The father considers that such irregularities are the real cause of his failure, and resolves, therefore, to pursue the same food supply policy in the coming as in the past year, but to enforce it with more energy and strictness. The energetic prosecution of a mistaken policy does no good; the previous difficulties remain and the discontent in the family increases."

Although this policy was urged by physiologists and economists, the instinct of the farmer to preserve at all costs his head of stock, combined with the political power of the land-owning class, prevented its adoption. Thus Germany endeavoured to

maintain unimpaired her large stock of horn cattle, so that in the famine times of June 1917 they amounted to 21,800,000 head, as against a little less than 21 million in 1913, the only slight diminution being in the number of cows. Though, at the beginning of the war, possibly as the result of the Eltzbacher Report, a certain reduction of pig stocks was undertaken, the reduction was never sufficient to allow of proper feeding of the animals that were left.

Thus large quantities of vegetable food and of food which might have been utilised by man were wasted in the mere maintenance of cattle and pigs without any production of meat or fat. The ill-fed cattle deteriorated in quality, their working powers diminished, the milk supply became less and less, and there was a fat famine throughout the land, with the final result of the physical and moral collapse of the population of Germany, which rendered further carrying on of the war impossible.

It must be remembered that the problem in front of the German administration was

incomparably more difficult than that which faced the British Government. Not only was there an actual deficiency of bread-corn, but the collection of supplies depended on the general good will and co-operation of the farmers, small and large. In all countries it has been found that the producers will satisfy their own accustomed needs before releasing food for consumption by others, and this in spite of penal measures or pecuniary inducements. In the United Kingdom the Government could control the markets by their control of imported supplies, forming over two-thirds of the food in the country, so that delinquencies on the part of the farmers were not so serious a factor as was any similar failure among the German producers. Each year it was thought that the war could not last another year. The Germans had banked on a short war, and on this supposition a drastic reduction of the live stock to one-half its previous amount must always have seemed a ruinous proposal. If they could have foreseen how long the war was to last, it would have been possible

to devise a scheme which would have provided a sufficient ration, including animal foods and fats, for the whole population; but even then the scheme might have suffered shipwreck from the selfishness of the producing class and the difficulty of controlling them in the interests of the state as a whole.

The United Kingdom

The conditions of the food supply in the United Kingdom differ so much from those in Germany that it might be thought that the provision of food in this country would present an altogether different problem to those just discussed. Scientific principles however do not alter, however great the modifications which have to be made in their application according to the circumstances of the case, and we shall find exactly the same questions and difficulties presenting themselves in the British food supply as we have seen occurring in that of Germany. This country had however the advantage of Germany's experience to serve as an example or warning.

During the second half of the last century a profound revolution was effected in the food production of this country. The Minister of Agriculture has pointed out recently that, whereas in 1841 our indigenous agriculture was feeding 24½ million of people out of a total population of 26 million, in 1914 it was feeding 17½ million out of a total population of 46 milllon. Whereas in 1841 the British housewife filled her larder and store for each meal except Sunday supper with home-grown food, in 1914 she depended on the foreigner for every meal for each day except from Friday evening to Monday morning, so that from the point of view of home production we had become a nation of week-end supply.

This change in the system of production was brought about by the necessity of accommodating to the importation of cheap wheat from the newly-developed wheat lands of America and the Colonies. Meat, rather than wheat, became the staple product of the country, and the attention of the farmer was concentrated on cutting down cost of labour and securing such profits as were possible

from grass farming, for which our climate is so well adapted.

As pointed out in a memorandum of the Food (War) Committee, the system was "successful from the standpoint of both landowners and farmers, for it restored to solvency the bankrupt agriculture of the 'nineties. It was also favourable to Britain's commercial policy, which cultivated the sea as systematically as it neglected cultivation of the land. When the policy took form, corn could easily be carried in ships, meat could not. By transferring our corn-fields to other lands, we were not only saved the necessity of tilling our own, but we provided valuable merchandise for sea transport."

But, even before the war, the position had been modified by the development of trade in chilled and frozen meat, though without any corresponding modification in the habits of the British farmer. Yet it cannot be doubted that the improvement of the cattle and sheep of other countries through the export of British sires, and the development in technical methods employed in shipping

meat, have wholly altered the agricultural position, and it has yet to be determined which form of farming will be most profitable for the farmer. A condition of things was certainly possible before the war in which production of food in this country—whether meat or wheat—would have been reduced to still smaller dimensions, the land being regarded simply as a luxury or means of pastime, and the nation being reduced to one living on the profits of its shipping and trading and importing all the necessaries of life, as has been the frequent fate of rich seafaring nations in times of peace.

In the first two years of the war our command of the seas left all the markets of the world open to our shipping, and, whatever the production of food in this country, there was no difficulty in supplying our needs by importation. Although merchant shipping had been diminished by diversion to warlike purposes, a sufficiency remained for the transport of both munitions and food. With the development of submarine warfare conditions were completely changed. The loss of

22 per cent. of our shipping, equivalent to nearly half of that available for trading purposes after satisfying military and naval requirements, rendered it impossible for the remaining ships to do the carrying that was required of them, if they made long voyages to such places as Australia and Java. All these distant markets therefore were shut out from us almost as effectively as though they had been in the hands of the enemy, and we were forced to draw our supplies entirely from the American continent.

Two other factors arose, making it difficult to obtain what we wanted in this limited market. One was lack of credit, due to the diversion of all our manufacturing energies into the supply of munitions; the other the fact that in 1917 there was a partial failure of the wheat harvest on the American continent. It became necessary therefore to turn to our home supplies and to consider how these could be saved or increased for the use of man.

The problem in many respects was similar to that which had already faced the Germans.

Since however supplies from abroad were not entirely cut off, we had further to consider what foods, among those that could be obtained, would be most profitable to import, and we had therefore to regard food production in the light of the conclusions so arrived at.

As in Germany, the policy indicated was to increase as far as possible the food available for man by planting more wheat, by ploughing up grass lands for wheat culture, by increasing the cultivation of potatoes, which yield so plentifully per acre, by diversion of grains such as barley, maize, and to a certain extent oats, to human food, instead of employing these for the fattening of animals, and by milling the wheat to a much higher percentage so that only 10–15 per cent. of offals were separated from the flour.

Thus in England, as in Germany, it was a question of man *versus* animal, of human food in the form of cereals and potatoes, rather than animal food produced at a loss of four-fifths of the energy of the feeding-stuffs employed. Such a policy could theoretically

be carried out to a much greater extent in the United Kingdom than in Germany, because a certain amount of imports was still possible, and it was always more economical of tonnage to carry the finished article rather than raw material—*i. e.* to import fats, bacon and meat, rather than to import the excess of grain and other feeding-stuffs which would have sufficed to produce this fat and meat on the farms of our own country.

The vigorous carrying out of the measures just described left very little for the nourishment of animals. The oats could not be used for man in any large quantity, since it was absolutely essential to maintain on the farms the working stock, without which no cultivation of the ground could take place. All the barley however was taken, a large amount of the maize which had been imported or which could be imported, and there was left over for the animals only 10–15 per cent. wheat offals, the rather larger percentage of offals derived from the milling of barley, and any spoilt grain that might be available. A certain amount of oil-cake would also be

obtainable from the crushing of the oil-seeds imported into this country for making the cheapest form of fat food, viz—margarine.

The total amount however was only a little over one-third of what was available for feeding animals, other than working horses, in the years before the war. Thus, in the years before the war, the total weight of concentrated feeding-stuffs available for animals was about 11 million tons, of which $3\frac{1}{2}$ million represented oats for working horses, leaving $7\frac{1}{2}$ million tons of concentrated feeding-stuffs for fattening purposes.

In 1917–18 the reduced importation and increased milling dropped the total to 7 million tons. As the proportion of oats was about the same as before, this left only about $3\frac{1}{2}$ million tons available for fattening of stock, pigs, fowls, etc. Such a big reduction in available food seemed to indicate the necessity of reducing the total head of stock in the country in order that the remainder could be fattened and produce fat meat, rather than maintain the whole head of live stock on a ration only just sufficient for

maintenance. Here however, as in Germany, the deeply-rooted instinct of the farmer to maintain his live stock prevented such counsels attaining fruition, and it is probable that the failure to reduce the stock would have resulted in still greater difficulties in our meat supply than were actually experienced during the winter of 1918–19, if the Armistice had not occurred on 11th November, allowing an immediate assignment of extra tonnage to bring in feeding-stuffs for our starving cattle.[1]

[1] It has been urged as an argument against any reduction in the live stock of a country that such a measure would deprive the farmer of the most valuable of his fertilisers, viz., farmyard manure. It is true that artificial manures can be used equally well for enriching the soil with nitrogen, but the rotted and fermented straw, which forms an essential constituent of farmyard manure, is endowed with certain physical qualities, which no artificial manure will replace and which render a soil treated with it more porous and retentive of moisture. Arable farming without stock means that a large part of the straw cannot be utilised and must be burnt, (as in the Canadian prairie-farms) while the soil gradually deteriorates in productive value. The whole question is one of proportion. The chief justification for the raising of stock for food is the provision of fat. It has never been proposed that in times of scarcity all live stock should be destroyed, but that it should be reduced to the minimum necessary: (*a*) for working the land; (*b*) for the production of milk; (*c*) for preserving the breed. For these purposes feeding stuffs must be

One can hardly repine however at such an interference with the course of an experiment which, though instructive, would have been extremely uncomfortable for the inhabitants of this country, and might even then have failed to be correctly interpreted by our farmers.

Apart from the question of reduction of the total head of stock, the diminished feeding-stuffs available were very properly rationed, so that a preference was given to the working animals, to the milch cows, and to breeding-stock, little or none being assigned for the fattening of cattle or pigs.

With a rational policy of food production, the policy of importation became equally obvious. The Cabinet, recognising the prime importance of maintaining the health

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provided, even if man has to go short. Only after man's Calorie needs (not his desires or necessarily his habits) have been satisfied, is it justifiable to use cereals for fattening animals for food. The number of animals fattened must then be limited by the amount of feeding stuffs available; no useful object is served by keeping a number of animals on a bare sustenance ration, so that they produce no fat, and by their numbers prevent the rearing of a more limited number of fat animals.

and efficiency of the country, gave the introduction of the necessary foods into this country the first call on available tonnage, those foods being such as could not be provided in this country or were deficient in quantity, the finished product—such as meat—taking priority over the raw material, feeding-stuffs, out of which meat might be made.

Thus the chief imports were wheat and flour to make good our home deficiencies, bacon and oil-seeds to supply the necessary fat, refrigerated meat and dairy produce—such as condensed milk, butter and cheese—and sugar. It is impossible within the limits of these lectures to give a complete description of the administrative measures which were necessary and employed, in order that the above principles might be put into effect. It may be worth while however to summarise the chief methods which should always be employed under similar conditions when, in times of general scarcity, it is necessary to divert the attention and energies of the farmer from the raising of

stock to the raising of corn, and where, to avoid general under-nutrition, the habits both of producers and of consumers must be modified so that the greatest possible amount of the energy in the form of food produced by the soil may be directly utilised by man.

The measures which should be employed for this purpose have been classified by Prof. T. B. Wood under five heads, and can be summarised shortly as follows :—

(1) Propaganda

If the farmers are to carry out the necessary changes intelligently, they must understand the reason for the policy adopted. They should be taught to sell their barley to the miller to be ground into flour and used for bread-making, rather than use it as food for poultry or pigs, because 7 lbs. of barley are necessary to make 1 lb. of pig meat, while the same amount of barley turned into flour would give 4·5 lbs. of bread, leaving enough offals over to produce $\frac{1}{4}$ lb. of pig meat if used for feeding pigs.

(2) Orders

While such advice as outlined in the last paragraph will suffice to induce the more patriotic and intelligent to follow the directions of the Government, the large majority will continue to follow their former practice and feed their pigs with barley unless the Government forbids altogether the feeding of animals with any cereals that can be made into bread. Failure to comply with these orders should be punished by a fine, so heavy that it will not pay the farmers to risk the penalty.

(3) Fixing of Prices

In order to obtain the proper partition of the properties of the soil between animals and man, it is necessary to fix the prices of cereals and of animals or meat in such a manner that it is more profitable to the farmer to sell his cereals and potatoes as human food than to employ them in fattening his animals. If maximum prices are fixed, they should be in the first place not for the products of the soil but for the food substances which the farmer creates out of these

products, so that it becomes unprofitable for the farmer to raise animals at the expense of food which could be used for man. Price-fixing is probably the most efficient means by which the best possible proportion of cereals can be obtained for human consumption. But it is a policy which is not unattended with danger if carried out unskilfully. It may interfere with production, and it gets rid of the free play of prices which is the motive power for distribution of produce between producer and consumer. High prices moreover are the best stimulus by which to increase production and to encourage personal economy. It is important that the price-fixing be so general that interference with the production of one kind of food does not produce undesirable over-production of another. The relative prices of different kinds of food should be adjusted according to the actual cost of production. Thus the relative prices of different cereals could be adjusted on the average prices for the last 15 years. On such a basis, if wheat is 60*s*. per quarter, barley should be 50*s*. and

oats 36*s.* Then, accepting the computation that 7 lbs. of barley are consumed in the production of 1 lb. of pork, the food required to produce 1 lb. of pork would cost $9\frac{3}{4}d.$ If therefore the maximum price of pork were fixed at 10*d.*,[1] pork production would be less remunerative than the selling of barley. Fuller examples of this rational method of price-fixing will be found in Wood's pamphlet on "National Food Supply in Peace and War." Without however the guidance of the physiological knowledge which results from the exact record of agricultural experience, great danger may be run in fixing for the different foodstuffs prices which are not properly inter-related.

(4) Power of Requisition

In addition to the above measures the Government must have the power to requisition at fixed prices either cereal stocks or live stock according to the needs of the

[1] These figures must be taken only as examples of the method. At the present time it would be necessary also to take into account the increased establishment charges rent, wages, etc.

country. In this way it is not only rendered impossible for the farmer to keep his stocks of barley for the surreptitious feeding of animals but, if he has in spite of regulations fattened his animals, he is forced to sell them at non-remunerative prices. The right of requisition would also render it possible for the Government to carry out a rational reduction of the live stock of the country, if such a policy had been decided on.

(5) Rationing

As a result of these measures the total supply of meat in the country will be diminished unless it is possible to supply the whole deficiency by means of importation, which, as we know, was not the case during the late food shortage. Since the price of meat is kept artificially low, and its consumption is not limited by the usual result of shortage—*i. e.* high prices—every one will try to buy it, so that there will be queues at butchers' shops, secret commissions for the privilege of obtaining meat, and general discontent. It is therefore necessary to deal

with the shortage by rationing meat, by limiting the consumption of each individual to a small definite amount.

By such measures it was found possible in this country to avoid the necessity of interfering with the free sale of bread in spite of a deficiency of two-fifths of the ordinary cereal imports into the country, while at the same time a reduced but sufficient ration of meat was provided for every individual.[1]

But it must be emphasized that no single one of the measures outlined above can be omitted without causing a failure of the others to attain their object—viz. such an economy of the food supplies of the country that every individual is adequately nourished in spite of a considerable reduction in the total food usually available.

[1] It should be noted that a bread subsidy does not appear among these measures. Any justification for a line of action, which is costing the country over fifty million pounds per annum, could only be as a temporary expedient for tiding over a period before wages had had time to be adjusted to the altered cost of living. A rise in the price of an essential food such as bread is properly met by a rise in wages. The retention of this subsidy at the present time, when wages have been increased to twice their pre-war level, can only be ascribed to political cowardice.

CHAPTER VI

THE DISTRIBUTION OF FOOD

UNDER the conditions hitherto existing, the State has to concern itself with the distribution of food only when operations of war have interfered or are promising to interfere with the play of the ordinary laws of supply and demand. Now that the State concerns itself with the minimum wage in different occupations, which in itself must be a function of the price and supply of foodstuffs, it might at any time happen, even during peace, that the operation of trusts and monopolies or a widespread failure of crops throughout the world might necessitate the direct intervention of the State in the feeding of and especially the distribution of food to the nation. In any such deficiency the experience gained during the present war cannot fail to be of inestimable value.

A shortage of food may be general or may be limited to one or two articles. But if these articles of food are of great importance in the dietary, their lack may bring about a secondary shortage of other foods, just as the deficiency of cereals in this country was the cause of a secondary shortage of meat and milk. Under some circumstances a partial shortage may be of no concern to the State. The immediate effect will be a rise of price in the article concerned, so that its consumption will be limited to the richer or richest classes. It is obviously of no importance if there is a failure in the supply of champagne, and even chickens and game might be absent from the table of the ordinary man without involving or calling for any action on the part of the State. But if the food in question is an article of general consumption, State action may be necessitated either by public discontent or by a real menace to the health of the nation. Thus, butter may be dispensed with if there is a sufficient supply of margarine, although the

absence of the accessory food factors from the latter renders it less desirable as an article of general and exclusive consumption. But a shortage of milk, which is practically essential to the well-being of the growing child, becomes a question which affects the welfare of the nation as a whole, and necessitates therefore action by the State.

On the other hand, health and efficiency may be maintained without the use of butcher's meat, provided that animal protein is available in the form of milk and cheese. But we have learnt that the population will dispense with meat only under severe necessity, and will then demand an equal distribution of the supplies that are available, irrespective of the means of the individual.

If the shortage of food affects the total supplies—*i. e.* if the total food is of insufficient Calorie value to meet the needs of the whole population—the intervention of the State is necessary in the first place to arrange increased production and to adjust importations. The key to this problem, as we have seen in the last chapter, is the

diversion of food from animals to man, and the provision of vegetable or cereal food at the expense of animal food. Whether however the shortage be general or partial, experience has shown that the State cannot confine its activities to the stimulation of production, but must itself control the distribution of food—*i. e.* some system of rationing must be set up.

The problem of rationing is by no means simple, as has been shown by the failures in the attempts to carry out this process, both in Germany and in the countries of our Allies and the Neutrals. Assuming that, by the means sketched out in the last chapter, the State has secured a total quantity of food with a Calorie value sufficient for the needs of the whole nation, it has then to ensure that this is distributed to each man, woman and child in proportion to each one's physiological needs, so that no one gets more and no one less than he or she requires for health and efficiency, whatever be his status, means, or occupation.

The problem is insoluble if the system is

complete and made to include all kinds of food, except in cases where large bodies of individuals of the same category are to be fed at the same time; *e.g.* 1,000 soldiers or workmen can be given the food necessary for the average individual in their category. Feeding at a common table, the individual differences which exist will adjust themselves, one man will eat more and another less than the average, but the total consumption will correspond to the average requirements. On the other hand, individual rationing, if complete, must fail. The individual requirements from man to man vary according to stature, environment, habit of body, duration of resting periods, degree of work. There are probably also individual differences dependent on the greater or less efficiency of the man as a machine. A woman with atrophied thyroid will take and consume only half the food of a normal individual; another with hypertrophied thyroid may take double the ration of the ordinary woman, though leading comparatively much the same life; and

smaller differences of the same kind probably exist very widely among the units of the population.

The rationing committee appointed by the Ministry of Food, foreseeing the possibility of a shortage of bread, attempted to draw up a nearly complete rationing system, and divided the nation into the following categories—

Class.		Cals.
1.	Men on heavy work	3,750
2.	Men on ordinary manual work, women and boys on heavy work	3,250
3.	Boys from 13 to 17 and girls on heavy work	3,000
4.	Men in sedentary occupations, women on ordinary work, girls from 9 to 17 and boys from 9 to 12.	2,450

The Royal Society approved of these figures, provided they could be taken as representing the physiological minimum. They pointed out that they left no margin for waste in distribution and that, although they might represent the average in each case, among heavy workers some might require up to 5,000 or even 6,000 Calories. In the case of compulsory rationing there-

fore, supplementary rations would be required by the heaviest workers.

The almost infinite variability amongst the needs of individuals is well brought out in a recent investigation by Carl Tigerstedt, in which the food actually taken by numbers of individuals is analysed and the average value determined. Thus, in 64 men the gross energy requirements vary between 4,613 Calories and 1,942 Calories, the average being 3,406 Calories, a figure almost identical with that assumed by the Royal Society for the needs of the average man.

Of these men the percentage distribution of the variations is shown in the following table—

Calories.	Number of Cases.	
	Actual.	Per cent.
> 4,500	3	4·7
4,000–4,500	11	17·2
3,500–4,000	12	18·8
3,000–3,500	16	25·0
2,500–3,000	18	28·1
2,000–2,500	3	4·7
< 2,000	1	1·6

In 57 women the Calorie intake per day varied between 5,041 and 1,106, the average being 2,226. An almost equal variability is shown among children, as is seen in the following table—

Group.	Age.	Total Calories.			Per Kilo Body Weight.			Per M^2. Body Surface.	No. of Cases.
		Max.	Min.	Average.	Max.	Min.	Average.		
I.	14	3,048	1,627	2,432	82	43	58	1,612	7
II.	13	2,924	2,155	2,468	70	57	62	1,714	4
III.	12	2,770	1,916	2,389	89	44	68	1,780	9
IV.	11	2,506	1,325	2,101	85	53	72	1,807	4
V.	10	1,836	1,798	1,814	70	60	64	1,697	3
VI.	9	2,751	1,777	2,277	102	79	89	2,124	3
VII.	8	2,030	1,614	1,817	85	67	76	1,774	3
VIII.	7	2,234	1,779	1,943	102	71	85	1,998	5
IX.	6	2,018	1,533	1,8 9	90	81	85	1,909	3
X.	5	2,032	1,388	1,652	114	73	96	1,991	4
XI.	4	1,557	1,130	1,344	104	81	93	1,836	2

In view of these facts it is not surprising that the attempt of Germany to provide sufficient food for all classes of the population, by a system of distribution in which practically all foodstuffs were rationed, proved a complete failure. No complete solution of the rationing problem will be arrived at, unless the impossibility of

complete individual rationing is accepted and it be recognised that, however widely the system be spread over the various foods, some important and complete food which is within the means of all classes of the population must be left free, so that each individual can buy of it according to his desire and satisfy his Calorie needs above those supplied in the rations.

No system can work without such a buffer substance or elastic reserve, and in Europe this free reserve should be bread. For the great mass of the population in Europe bread is the main source of energy. It may form 60 per cent. of the diet of the agricultural labourer. It is the cheapest form of energy and, containing as it does both carbohydrates and proteins, it is a nearly complete food and, with sufficient green vegetables, will support life effectually if a small amount of fat can be also procured. Thus poverty or a greater scarcity of provisions as a whole is always attended by an increase in the relative amount of bread eaten, since, however

much bread may go up in price, the shortage of cereals and feeding-stuffs will cause a still more pronounced rise in the price of other foods.

Thus any shortage of bread must cause widespread hardship as well as industrial inefficiency and unrest. On the other hand, provided bread can be kept free and available for all classes, any other foods can be rationed or limited in quantity without giving rise to actual hunger in any class of the population.

But, during the last years of the war, the shortage with which the European countries —including the United Kingdom — were faced, was a shortage of cereals, specially wheat, and therefore of the material out of which bread could be made. The obvious, but the wrong, policy for this shortage, and the one adopted in every country except our own, was to ensure an equal distribution of bread by limiting its consumption and by rationing it to the individual, the quantity per individual being regulated according to category, whether man, woman, light or heavy worker.

We have already seen the futility of such classification when we are dealing with a food which is the mainstay of the labouring population and the source of the greater part of the Calories they require. The key-note of the policy of the United Kingdom, on the other hand—a policy strongly urged from the beginning on the Ministry by the Royal Society Food (War) Committee—was that at all costs bread must remain unrationed. This at once necessitated the policy sketched out in the last chapter—viz. the increase by all means possible of the amount of cereal food which could be made into bread. It involved diversion of food from animals to man, higher milling of wheat up to as much as 91 per cent., the confiscation of barley and maize and rice, and their admixture with coarse wheat flour so as to produce a Government flour (G.R. Flour), which alone was allowed to be sold or used. If these measures failed to provide enough bread, the Cabinet determined to give cargoes of cereals priority over all other shipping, whether of men or of munitions of war.

This policy had two effects:—In the first place the bread was made unattractive, and in some instances even nasty, while its wholesomeness was in no wise diminished—in fact, it was rather richer in accessory food substances than is ordinary white bread. Thus it could be ensured that no excess of this bread would be eaten beyond the amount dictated by imperious hunger, while it was certain that, however hard the labours of an individual, he could always obtain sufficient energy in his food. On the other hand, every effort by propaganda and otherwise was made to reduce the consumption of cereals and to provide other foods which might take their place, encouragement being given specially to the production of potatoes. For this purpose the system of State subvention, by which the price of bread was prevented from rising beyond 9*d.* per 4 lb. loaf, was also extended to the encouragement of the cultivation of potatoes.

But the second result, as we have seen, was a necessary diminution in the production of meat and fat. The food habits of the

country demanded the provision of some meat in every one's diet. The Royal Society advised therefore, and the Government adopted, rationing of meat and of fat, and, since bread and cereals were left out of the scheme of rationing, it was possible to adopt a flat rate for fat and meat in the same way as had been previously done in the case of sugar. Fish was left unrationed, since its supply is so extremely variable, and the facilities for its cold storage so deficient that no uniform rate could be adopted. At one time the market may be flooded with fish; at another time the supply may be extremely scanty. It might in the same way have been necessary to ration milk, but the absolute need for milk is confined to the younger members of the population, and it was found possible, by means of a scheme in which preference was given to children and nursing mothers, to leave this question to local authorities and to the local distributors, such regulations only being passed as would prevent its undue use by adults in shops and restaurants.

It is evident that the maintenance of the free purchase of bread, as well as of a flat rate allocation of sugar, meats and fats, demanded a strict scientific adjustment of the importation programme. The general principles of such a programme were laid down by the Food (War) Committee as follows—

"Cereals and fats may be regarded as furnishing all that is absolutely required for the maintenance of health and efficiency in the great proportion of the population, assuming that a sufficient quantity of fresh foods, vegetable and animal, are available (*e.g.* greenstuffs, milk and butter), in order to supply the necessary factors in the diet. Most of the population would feel severely anything like a complete privation of the two other important foods, sugar and meat, and many of them would probably suffer in efficiency if not in health, unless a certain amount of these were supplied. We arrive therefore at the following conclusions as regards the order of importance of foods and of their preferential importation—

"1. A sufficient amount of cereals should be imported as breadstuffs to avoid rationing and to serve as an elastic reserve for the energy needs of the country, and all cereals in the country should be reserved as breadstuffs to meet the full demand for these.

"2. A minimum of 16 ozs. of fat should be provided per head per week, taking into account not only the meat, fat and margarine, but also the fat contained in milk, wheat and other foods available.

"In order to bring up the fat of the food to this amount the necessary quantity of bacon, fat meat, and oil seeds must be imported and the home supplies conserved by limiting their use for industrial purposes.

"3. A minimum supply of sugar of 8 ozs. a week per head must be supplied. Up to these figures, which the Committee regard as minimal, the import of food into

this country should take preference of all other claims on shipping.

"4. Any tonnage then available for supplying this country with food should be utilised to bring the meat ration up to 2 lbs. per head per week."

In these lectures I have brought before you a series of principles on which any scientific control of the feeding of a nation must be founded. To a large extent the policy of the Food Ministry was guided by these principles, and the success of the measures taken is strict evidence that they are in the main correct.

With the exception of a temporary shortage in fats during the early part of 1918, which incommoded our population but was not attended by any noticeable ill effects on health and efficiency, the United Kingdom was the only nation in Europe in which no man, woman or child had to go hungry or leave his or her hunger unsatisfied on

account of war conditions. Indeed the general health of the community was better than in pre-war years, largely owing to the improved feeding of the poorer classes, among whom so many had previously been ill-nourished. The great diminution of sickness among elementary school children is a fact of much significance in this connection.

But the story I have unfolded is only a one-sided account of the business of food control. I have given no idea—indeed, I am not competent to do so—of the complex administrative machinery which had to be devised in order that these principles might be carried into effect. To ensure an equable and equitable distribution of food the State had to assume complete control over the production of food in this country, its importation, and its wholesale and retail distribution, while avoiding the danger of destroying the whole complex mechanism of distribution which had existed before the war. This machinery included the men who were acquainted with all the minutest details of the business in which they were

involved, and would be carrying on the work after the war. It was also imperative to avoid any risk of diminishing by interference the production of food.

The keynote of the administration was to employ so far as possible in the service of the State the whole economic machine evolved in peace-time for the distribution of food, abolishing however the incentive of competition and private gain and assuring to each man employed merely what was considered as a reasonable return for his labour. Whether the system was as economical as when free and uncontrolled may be doubted, but at any rate it succeeded in its object. So striking indeed was its success that we might be tempted to draw conclusions in favour of socialisation of the whole mechanism of distribution in this country. It should be remembered however that a prominent factor in determining the success of the administration was the willing co-operation of all classes. Habits and appetites were interfered with, but, whenever the reason for such interference was understood,

there was ready acquiescence even by those who were put to the most inconvenience. The nation was out to win the war and was ready to support any measure which seemed designed to attain this object.

APPENDICES

I. Table showing average compositions and Calorie values of the more important foods, adopted by the Inter-allied Scientific Food Commission for calculating the value of the food production and importation in a whole country.

II. Table showing the average yearly quantity of the total food consumed by man in the United Kingdom during the five pre-war years 1909–1913.

APPENDIX 1

TABLE OF COMPOSITION AND CALORIE VALUE OF THE MORE IMPORTANT FOODS ADOPTED BY THE INTER-ALLIED SCIENTIFIC FOOD COMMISSION.

THE figures are based for the most part on the analyses of American Foods, as given in Bulletin 28 (revised edition) of the United States Department of Agriculture, the averages adopted being on the lines of the Report of the Royal Society Food (War) Committee (Cd. 8421). In calculating the Calorie value from the composition, the factors used were—

		Calories
1 gr. Protein	=	4·1
,, Fat	=	9·3
,, Carbohydrate . . .	=	4·1

In estimating the food resources of the different allied countries, the Commission decided to take no account of the Calorie value of alcoholic drinks (Beer, Wine, Spirits), whether home produced or imported.

COMMODITY.	Protein. %	Fat. %	Energy value per kilo. Calories.
Cereals—			
Wheat and barley flour	11·5	1·0	3,640
Oatmeal.	16·0	8·0	4,000
Barley meal	10·5	2·2	3,600
Tapioca, sago, arrowroot, etc. . . .	8·3	0·6	3,650
Maize meal	7·5	4·2	3,500
Rice	8·0	0·3	3,540
Meat—			
Beef (United Kingdom, Pre-war) . .	14·5	22·5	2,690
Beef (United Kingdom (War time), and other countries)	15·0	18·0	2,290
Veal	16·0	6·3	1,230

COMMODITY.	Protein. %	Fat. %	Energy value per kilo. Calories.
Meat (continued)—			
Mutton (United Kingdom, Pre-war)	13·5	30·0	3,340
Mutton (United Kingdom (War time), and other countries)	13·5	24·0	2,790
Lamb	15·0	18·9	2,370
Bacon	9·5	60·0	6,000
Ham	14·5	34·0	3,750
Other pig meat (fresh pork)	10·0	40·0	4,120
Meat offals	20·0	10·0	1,750
Poultry, Eggs, etc.—			
Poultry (and Game)	15·0	9·5	1,500
Eggs (at 2 oz.)	12·0	9·5	1,400
Rabbits, imported (excluding skins)	21·7	10·8	1,900
Fish—			
Herrings	11·6	4·0	850
Other fish, fresh	10·0	1·0	500
Shell fish (without shell)	5·0	1·5	350
Canned and salted fish	20·6	10·3	1,800
Dairy Produce—			
Milk	3·3	3·7	700
Butter	1·0	85·0	7,950
Cheese (United States and United Kingdom)	25·0	30·0	4,000
Cheese (France and Italy)	25·0	29·0	3,700
Condensed milk, unsweetened	9·6	9·3	1,700
Condensed milk, sweetened	8·8	8·3	3,300
Margarine	1·2	83·5	7,800
Lard	2·2	94·0	8,800
Fruit—			
Apples	0·3	0·3	480
Bananas	0·7	0·4	600
Oranges	—	—	350
Nuts	6·5	22·8	2,600
Fruits, fresh	0·7	0·4	500
Fruits, preserved (without sugar)	2·0	2·0	2,800

COMMODITY.	Protein. %	Fat. %	Energy value per kilo. Calories.
Vegetables—			
Chestnuts	—	—	2,000
Potatoes	1·8	0·1	700
Beans, Peas and Lentils (dried)	24·3	1·3	3,600
Green Peas and Broad Beans (shelled)	7·0	0·5	1,000
Other vegetables	0·75	0·15	200
Preserved vegetables (bottled and canned)	1·5	0·3	380
Sugar, Cocoa, etc.—			
Cocoa (and chocolate)	15·0	34·0	4,800
Sugar (taken as refined)	—	—	4,100
Molasses	1·0	—	2,300
Glucose, solid	—	—	3,400
Glucose, liquid	—	—	3,200
Olive Oil (refined)	—	100·0	9,300

APPENDIX II

Quantities (in metric tons) of Total Foodstuffs (Imported and Home-produced) consumed each year for Average of Five Years 1909–13, and equivalent Energy Values (in millions of Calories) based on Calorie values adopted by the Inter-allied Scientific Food Commission.

	1909-13.			
	Quantity.	Protein.	Fat.	Energy Value.
Cereals—				
Wheat and barley flour	4,325,000	497,000	43,000	15,743,000
Oatmeal	200,000	32,000	16,000	800,000
Barley meal	50,000	6,000	2,000	180,000
Tapioca, etc.	100,000	8,000	1,000	365,000
Maize meal	50,000	4,000	2,000	175,000
Rice	140,000	11,000	—	496,000
TOTAL of Cereals	4,865,000	558,000	64,000	17,759,000
Meat—				
Beef (home)	820,000	119,000	185,000	2,206,000
,, (foreign)	491,000	74,000	88,000	1,124,000
Mutton (home)	294,800	40,000	88,000	985,000
,, (foreign)	182,200	25,000	44,000	508,000
Lamb	120,000	18,000	23,000	284,000
Bacon	308,000	30,000	185,000	1,848,000
Hams	64,000	9,000	22,000	240,000
Other pig meat	345,000	34,000	138,000	1,421,000
Meat offals	60,000	12,000	6,000	105,000
TOTAL Meat	2,685,000	361,000	779,000	8,721,000

	1909–13.			
	Quantity.	Protein.	Fat.	Energy Value.
Poultry, etc.—				
Poultry and Game .	55,000	8,000	5,000	82,000
Eggs (2 oz. each) . .	258,000	31,000	24,000	362,000
Rabbits (ex skins) .	18,000	4,000	2,000	34,000
TOTAL Poultry, etc. .	331,000	43,000	31,000	478,000
Fish—				
Herrings . . .	162,000	19,000	6,000	138,000
Other Fish (Fresh) .	636,000	64,000	6,000	318,000
,, ,, (Shell) .	12,400	1,000	—	4,000
Canned and Salted .	38,000	8,000	4,000	68,000
TOTAL Fish . .	848,400	92,000	16,000	528,000
Dairy Produce—				
Milk and cream . .	4,500,000	149,000	166,000	3,150,000
Butter	321,000	3,000	273,000	2,552,000
Cheese . . .	147,000	36,000	44,000	588,000
Cond. Milk (unsweetened) . . .	2,200	—	—	4,000
Cond. Milk (sweetened)	53,000	5,000	4,000	175,000
Margarine . . .	118,600	2,000	99,000	925,000
Lard	90,000	2,000	85,000	792,000
TOTAL Dairy Produce	5,231,800	197,000	671,000	8,186,000
Fruit—				
Apples	290,000	—	—	139,000
Bananas . . .	150,000	1,000	1,000	90,000
Nuts	38,000	2,000	9,000	100,000
Fruits, fresh . . .	644,000	5,000	3,000	322,000
,, preserved without sugar . . .	149,000	3,000	3,000	417,000
TOTAL Fruit . .	1,271,000	11,000	16,000	1,068,000

	1909–13.			
	Quantity.	Protein.	Fat.	Energy Value.
Vegetables—				
Potatoes . . .	4,250,000	77,000	4,000	2,975,000
Beans and Peas (dried) .	116,000	28,000	2,000	418,000
,, ,, (green) .	100,000	7,000	1,000	100,000
Other vegetables . .	995,000	7,000	1,000	199,000
,, ,, (preserved) . . .	21,000	—	—	8,000
TOTAL Vegetables .	5,482,000	119,000	8,000	3,700,000
Sugar, Cocoa, etc.—				
Cocoa and Chocolate .	36,000	5,000	12,000	173,000
Sugar (as refined) . .	1,525,000	—	—	6,252,000
Molasses . . .	33,000	—	—	76,000
Glucose (solid) . .	18,000	—	—	61,000
,, (liquid) . .	45,000	—	—	144,000
TOTAL Sugar, Cocoa, etc. . . .	1,657,000	5,000	12,000	6,706,000
TOTAL Food		1,386,000	1,597,000	47,146,000
Per head per day (45·2 million × 365)		84·0	96·8	2858
Per 'man' per day (÷0·835) . .		100·6	115·9	3422

The figures for yield of crops and for numbers of live stock and weight of fish are taken from the annual official Reports of the Board of Agriculture and Fisheries.

The estimates of Poultry, Game, and Dairy Produce are based on the Census of Production taken by the Board of Agriculture and Fisheries in 1908. The figures are substantially in accord with those given in the Report of the Food (War) Committee of the Royal Society on the Food Supply of the United Kingdom (Cd. 8421).

The figures for consumption of wheat flour are based on a census of the output of mills taken in 1907 by the Board of Trade and

recorded in the Census of Production. The figure given corresponds to an extraction of about 67 per cent. from the total home-grown and imported wheat.

The figures for oatmeal, barley meal, and maize meal are approximate estimates made by the Royal Society Food (War) Committee (Cd. 8421).

The rest of the figures are based upon the known imports recorded in the accounts of Trade and Navigation.

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